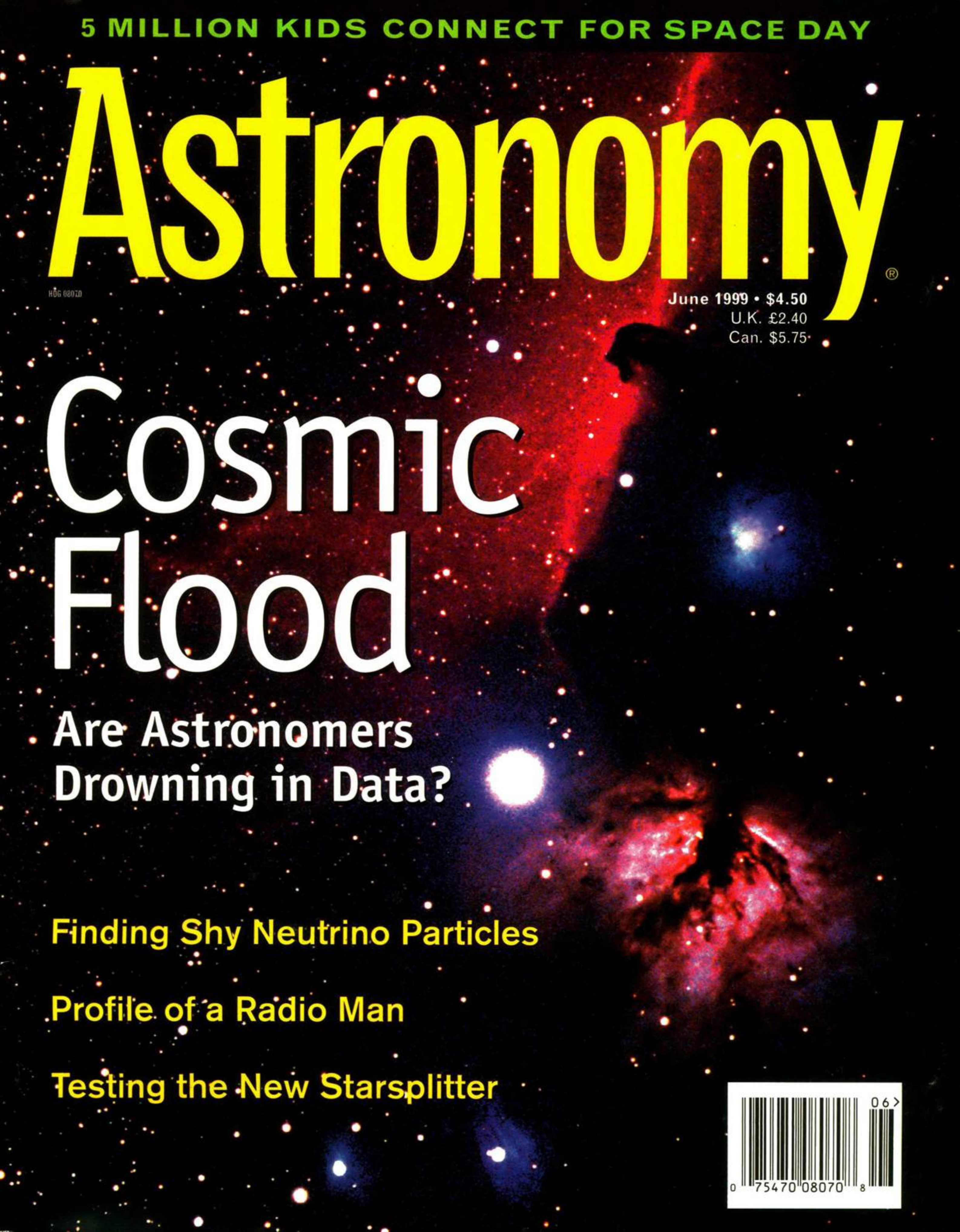

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Finding Shy Neutrino Particles

Profile of a Radio Man

Testing the New Starsplitter

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Now, ETX pushbutton electronic control — for only *$595* complete!

Already the largest-selling modern telescope in the world, the Meade ETX has been re-engineered for 1999 to provide the very latest in microprocessor-controlled capability.

New Fork Mount Design with Standard-Equipment Dual-Axis Drive System: The ETX-90/EC's fork mount includes high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use the hand controller at any of four dual-axis speeds: 8x for image centering in the main telescope at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

Cordless Operation: The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base. Or use the optional 25 ft. auto cigarette lighter cord that plugs into the telescope's control panel.

Optional Autostar™ Capability: Plug in the optional Meade Autostar computer controller *(see facing page)* for LX200-type operation, including automatic GO TO capability to more than 12,000 celestial objects.

Plus the features that created the ETX revolution:

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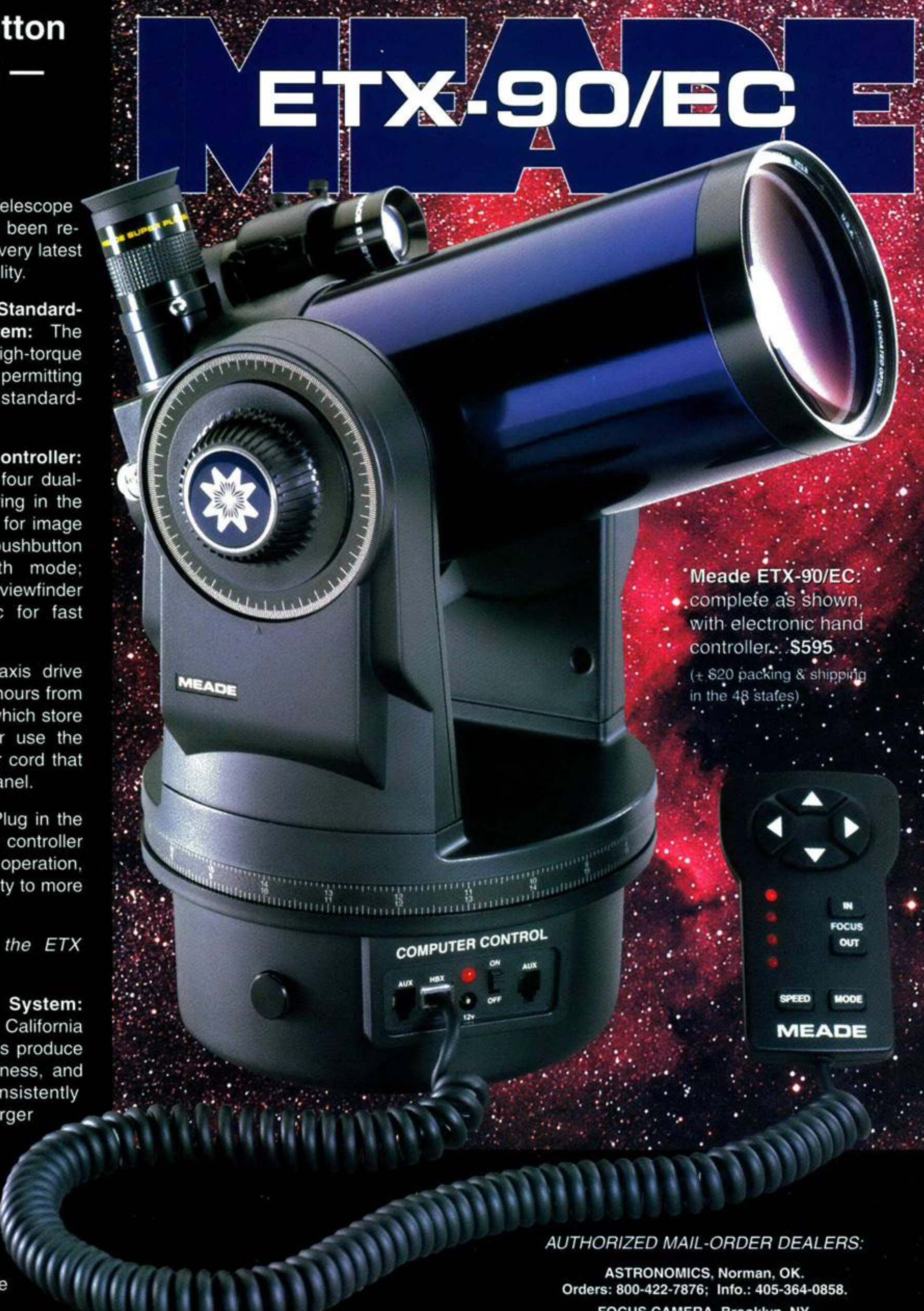
Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

SPECIFICATIONS: ETX-90/EC Astro Telescope — Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. Net weight 9 lbs. — **$595** (+ $20 P & S).

MEADE ETX-90/EC



Meade ETX-90/EC: complete as shown, with electronic hand controller... **$595**
(+ $20 packing & shipping in the 48 states)

OPTIONAL SYSTEMS FOR ETX-90/EC

#497 Autostar Computer Controller	$149.00
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#825 8 x 25mm Right-Angle Viewfinder	49.95
#774 Hard Carry Case	99.95
#932 45° Erecting Prism	49.95
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#1244 Electric Focuser, plugs into control panel	119.95

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RIVERS CAMERA, Dover, NH.
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SHUTAN CAMERA & VIDEO, Chicago, IL.
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Orders & Information: 416-783-4140.

Add the Meade Autostar™ hand controller to your ETX-90/EC for fully automatic GO TO object location ...only *$149!*

ETX AUTOSTAR
RA = 08:04.6
Dec = +36°38
MEADE
ENTER
MODE
GO TO
1
2
3
4
5
6
7
8
9
0
?

Plug the #497 Autostar Computer Controller into your ETX-90/EC and you're ready for an incredible array of LX200-type capabilities:

Automatic dual-axis GO TO function at 5°/sec to any of more than 12,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters — the best objects from the IC, NGC and Caldwell catalogs, as well as all 110 Messier objects); 900 stars (double stars, variable stars, SAO stars); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; 50 earth-orbiting satellites; plus user-defined objects and the centroids of all 88 constellations. Select any of these objects, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field.

Automatic GO TO function to *any* object of known R.A. and Dec.

Digital readouts of telescope position (continuously in R.A. and Dec.), menu options, glossary, and utility functions.

Precise sidereal-rate tracking in either altazimuth or equatorial modes. For altazimuth tracking, set the telescope on its drive base and perform a quick, easy alignment.

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The Meade #497 Autostar Computer Controller *(shown actual size)* plugs in directly to the control panel of the Meade ETX-90/EC and permits LX200-type automatic object location from a 12,000-object database, a database that includes virtually every astronomical object visible with the ETX-90/EC telescope. **$149.**

MEADE
COMPUTER CONTROL
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(right) **Meade ETX-90/EC,** shown with optional #497 Autostar Computer Controller plugged into the telescope's control panel.

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Patents pending on ETX-90/EC and Autostar.

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COVER PHOTO: Jerry Lodriguss

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So elusive they zip through Earth unscathed, neutrinos carry vital information about the sun's core, supernovae, gamma-ray bursts, and other enigmatic objects. *Ivan Semeniuk.*

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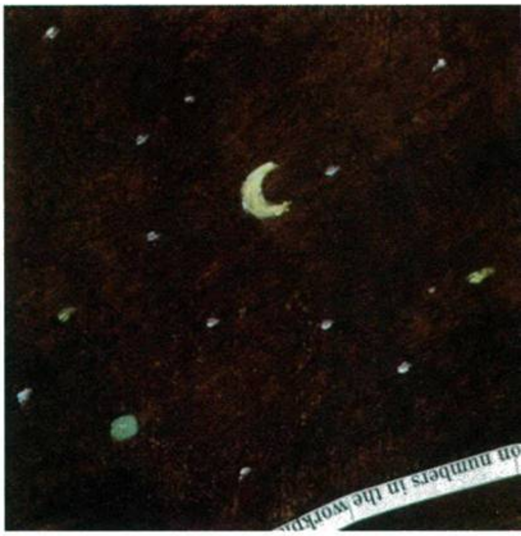
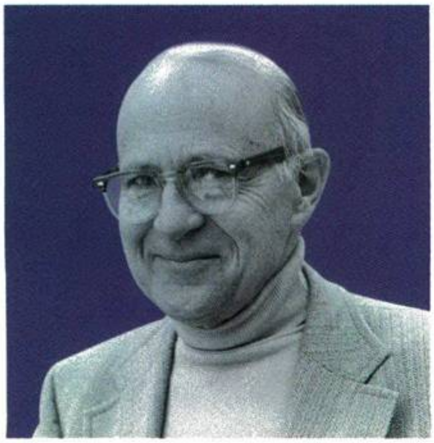
Sudbury Neutrino Observatory/Bob Chambers



76 Celestial Portraits

From *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.



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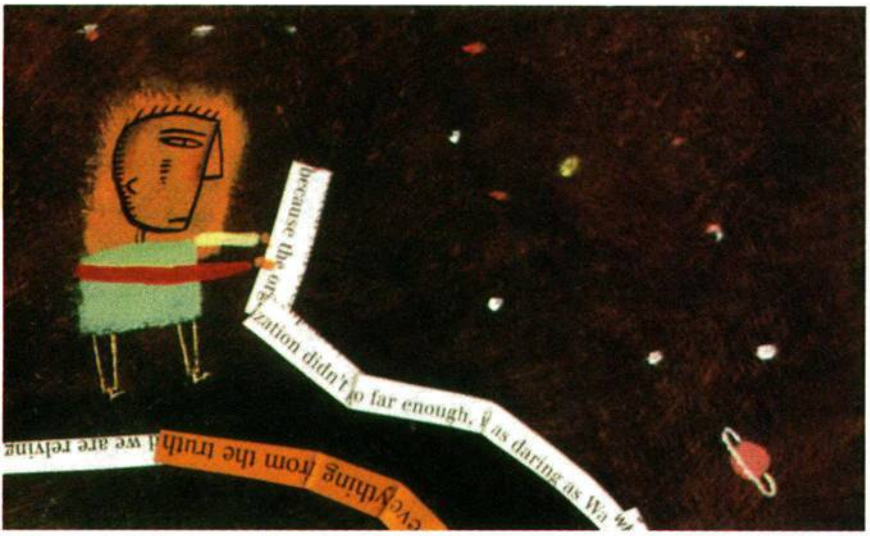
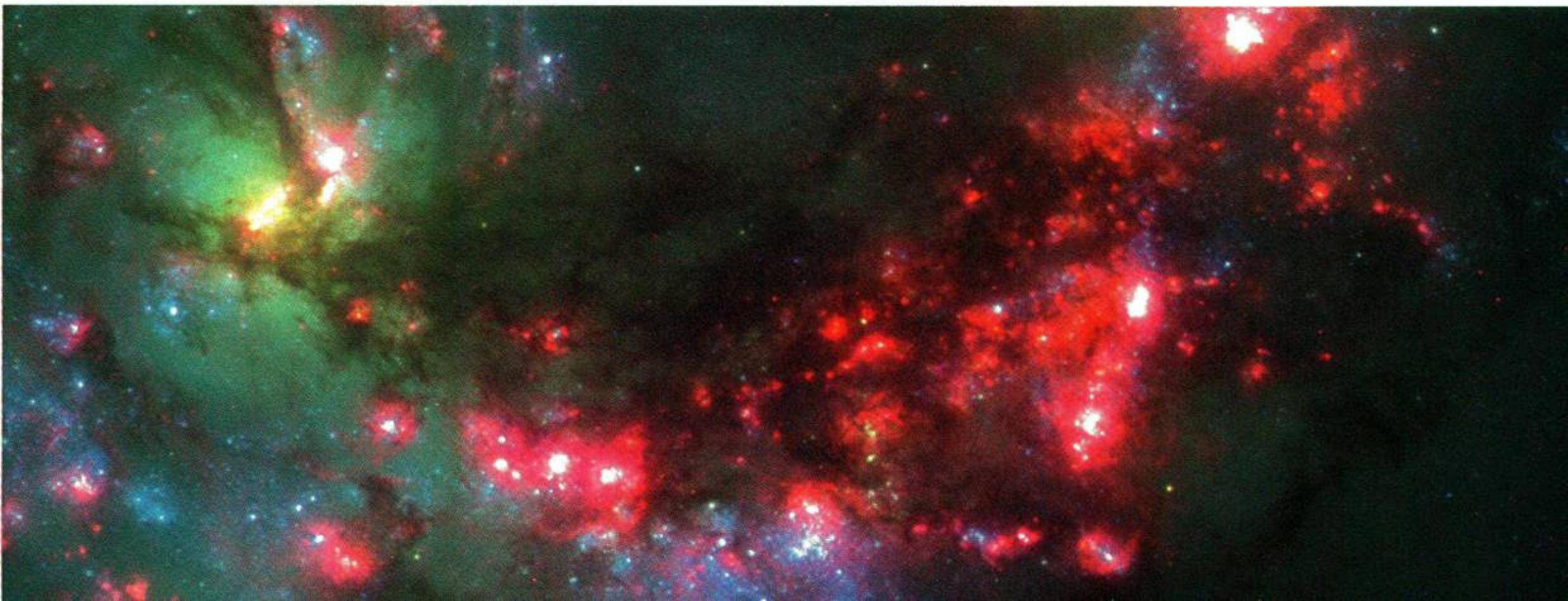


50 Five Million Kids Connect for Space Day Brad Whitmore/STScI



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Astronomy: Jim Forbes

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Roving Around JPL

Bedazzled by California bungalows on the residential streets of old Pasadena, I had a difficult time finding my way to NASA's Jet Propulsion Laboratory. I arrived late and cranky to tour this hill-cradled, hyperactive nest of space invention. My host Frank O'Donnell, manager of media relations for JPL, guided me briskly through Mission Control and then stopped to show me a couple of "clean" rooms. A communications satellite was being assembled in one of them. Before I had been in the lab long enough to acclimate to its heady history and rather chaotic architecture, Frank led me up a long flight of stairs. My eyes barely cleared the top step when I spotted Mars Sojourner. She was creeping straight toward me across a parking lot. "No," said Frank, smiling, "That's Rocky 7, not Sojourner. We left her on Mars, remember?" I remembered an instant too late. Rocky 7 is a model for the next Mars rover that will be named for Madame Curie.

Marie Curie will arrive on Mars in 2001 if projections hold, and JPL robotics engineer Samad Hayati told me she'll be smarter and more independent than her older sister. She'll have stereo cameras and an articulated mast, a long metal arm that will bend and extend as needed to get bigger views of the landscape. She'll be powered for longer use.

Like her model, Marie Curie will travel in careful spurts and then stop to check out the surroundings before she makes another move. Today Rocky 7 is traveling a mere 25 centimeters before taking a look around. If her solar sensors become blocked from the sunlight, she will stop and turn aside trying to avoid whatever is blocking the sun —perhaps a troublesome rock. Rocky's in training for the hazards Sojourner found on Mars. So far she has gone two kilometers, testing both JPL's new Mars Yard and the Mojave Desert — and worn out two sets of titanium tires.

In 2003 and 2005, other rovers will go to Mars — bigger rovers. A model for them, called Fido, is ambling around in some other lab at JPL. The new rovers will look like Sojourner and Marie, but they'll be bigger. Their platforms will be longer in front to support a drill for taking martian soil samples.

As we returned to the Lab's entrance, Frank waved to Matthew Golombek, project scientist on Pathfinder. Matt was moving ahead of us at a fast clip, and I could tell he didn't want to stop for a chat. The way Frank pointed him out to me is similar to the way my daughter, trying to signal me to stay cool, points out Hollywood stars. Matt, after all, was on the nightly news regularly during Sojourner's summer. His fresh face and easy style made him almost as big a celebrity as the rover herself. He just falls short of her in charm, perhaps because she so resembles a retro skate — the kind we used to clamp onto our shoes to roll around the sidewalks of Chula Vista in the 1950s.

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(+ $65 packing and shipping in the 48 states)

(shown with optional #1702 Drive System)

Model 203SC/500: 8" f/10 Schmidt-Cassegrain Telescope

$895

(+ $65 P & S)

Model 102ACHR/300: 4" f/9 Achromatic Refracting Telescope

$595

(+ $55 P & S)

Model 102ACHR/500: 4" f/9 Achromatic Refracting Telescope

$695

(+ $55 P & S)

LXD 300 **Now you can buy a Meade® 8" f/10 Schmidt-Cassegrain Telescope, complete with LXD 300 equatorial mount, rigid full-length aluminum tripod, and accessories for only $795! Or a Meade 4" f/9 Achromatic Refractor, complete, for only $595!**

Choose either the Meade 203SC/300, with the exact same optical tube assembly as more expensive Meade 8" Schmidt-Cassegrains, or the Model 102ACHR/300 with its exquisite 4" Meade air-spaced achromatic lens. Both telescopes are equipped with the high-performance Meade LXD 300 equatorial mount with dual-axis aluminum worm gears.

SPECIFICATIONS: Models 203SC/300 and 102ACHR/300 — Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 300 equatorial mount with aluminum worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 50°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions. **8" — $795** (+ $65 P & S); **4" — $595** (+ $55 P & S); **#535 R.A. Motor Drive System**...**$99; #812 Polar Alignment Finder**...**$49.**

LXD 500 **For even broader capability, use the Meade® high-precision LXD 500 equatorial mounting, 20% larger and with dual-axis bronze worm gears — the finest equatorial mounting available in its price class.**

SPECIFICATIONS: Models 203SC/500 and 102ACHR/500— Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 500 equatorial mount with oversize bearings, high-precision bronze worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 60°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions **8" — $895** (+ $65 P & S); **4" — $695** (+ $55 P & S); **#1701 R.A. Motor Drive System** with 4-speed controller...**$145; #1702 Dual-Axis Drive System** with 4-speed controller...**$195**; **#812 Polar Alignment Finder**...**$49.**

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- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.
- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.
- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*.
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

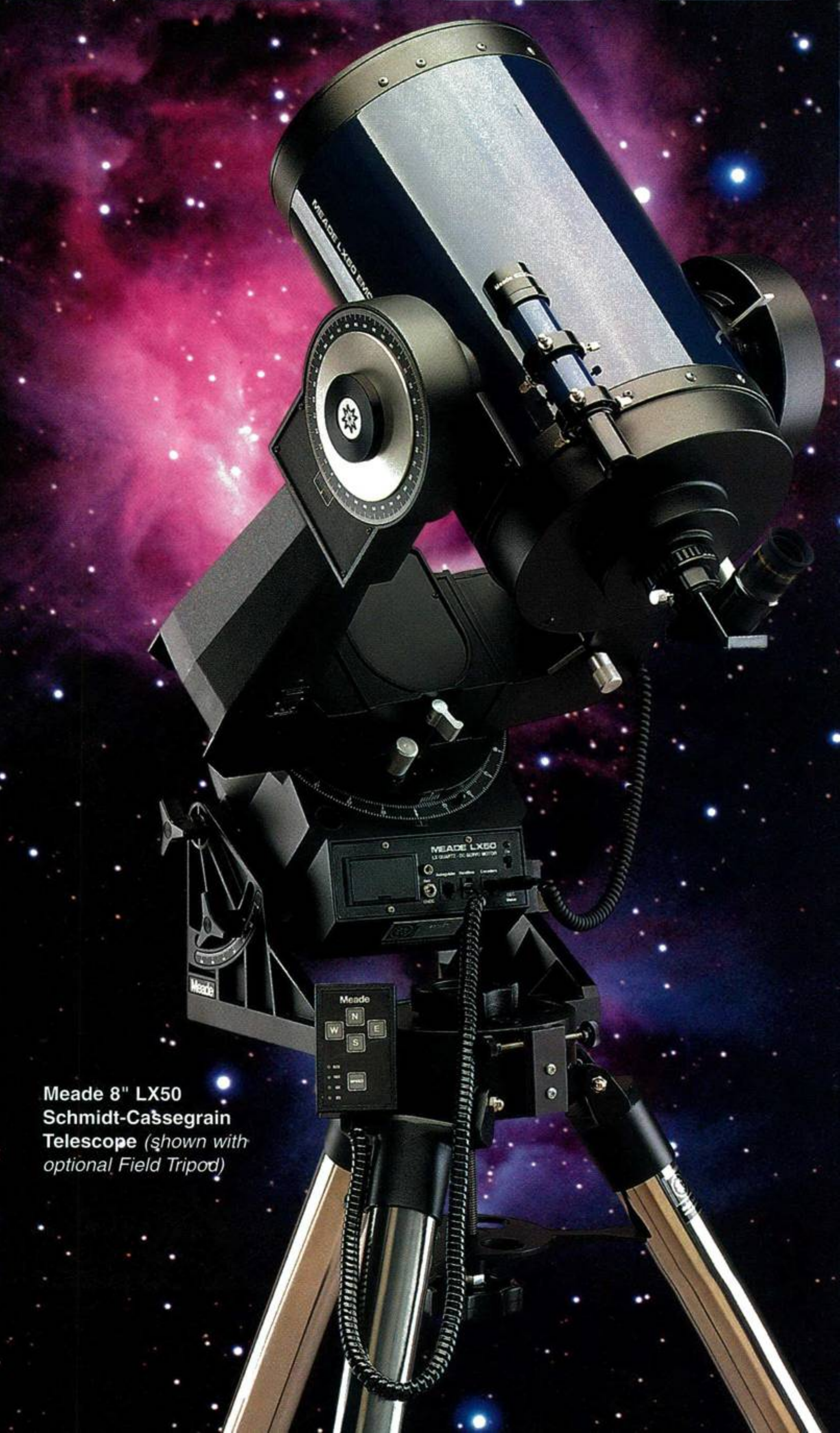
SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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Meade 10" LX200 Schmidt-Cassegrain Telescope

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Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- 1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- 1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- 2 - **Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
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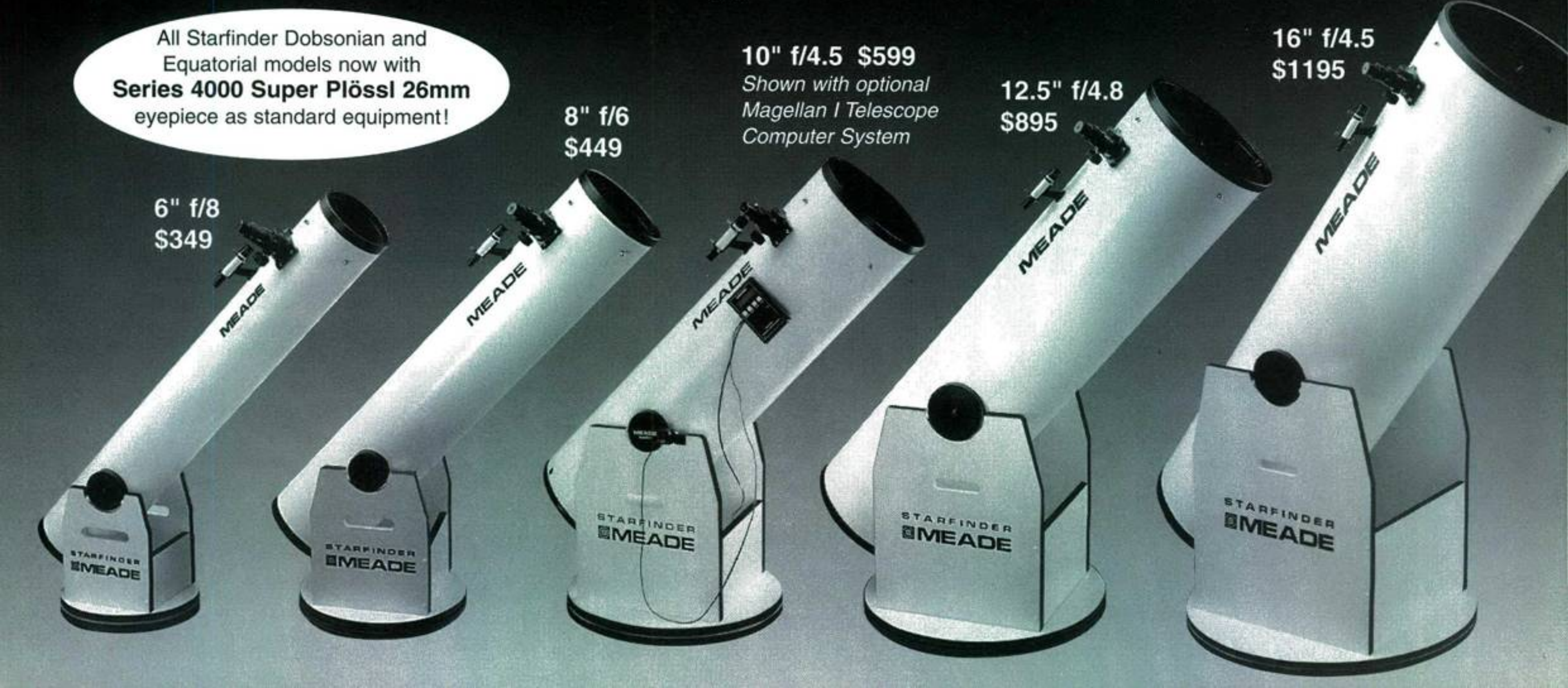
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***



All Starfinder Dobsonian and Equatorial models now with **Series 4000 Super Plössl 26mm** eyepiece as standard equipment!

6" f/8
$349

8" f/6
$449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12.5" f/4.8
$895

16" f/4.5
$1195

MEADE
STARFINDER EQUATORIALS

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

MEADE
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MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
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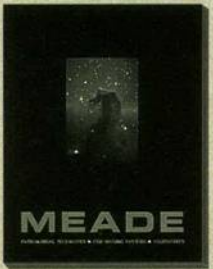
Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*



The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 100-page Meade General Catalog.

Write, call, or fax Meade Instruments for your free copy!

To Order: Contact your authorized Meade Advanced Products Mail-Order Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

ADVANCED PRODUCTS DIVISION

Meade Instruments Corporation

World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
6001 Oak Canyon, Irvine, California 92620 ☐ (949) 451-1450
FAX: (949) 451-1460 ☐ *www.meade.com*

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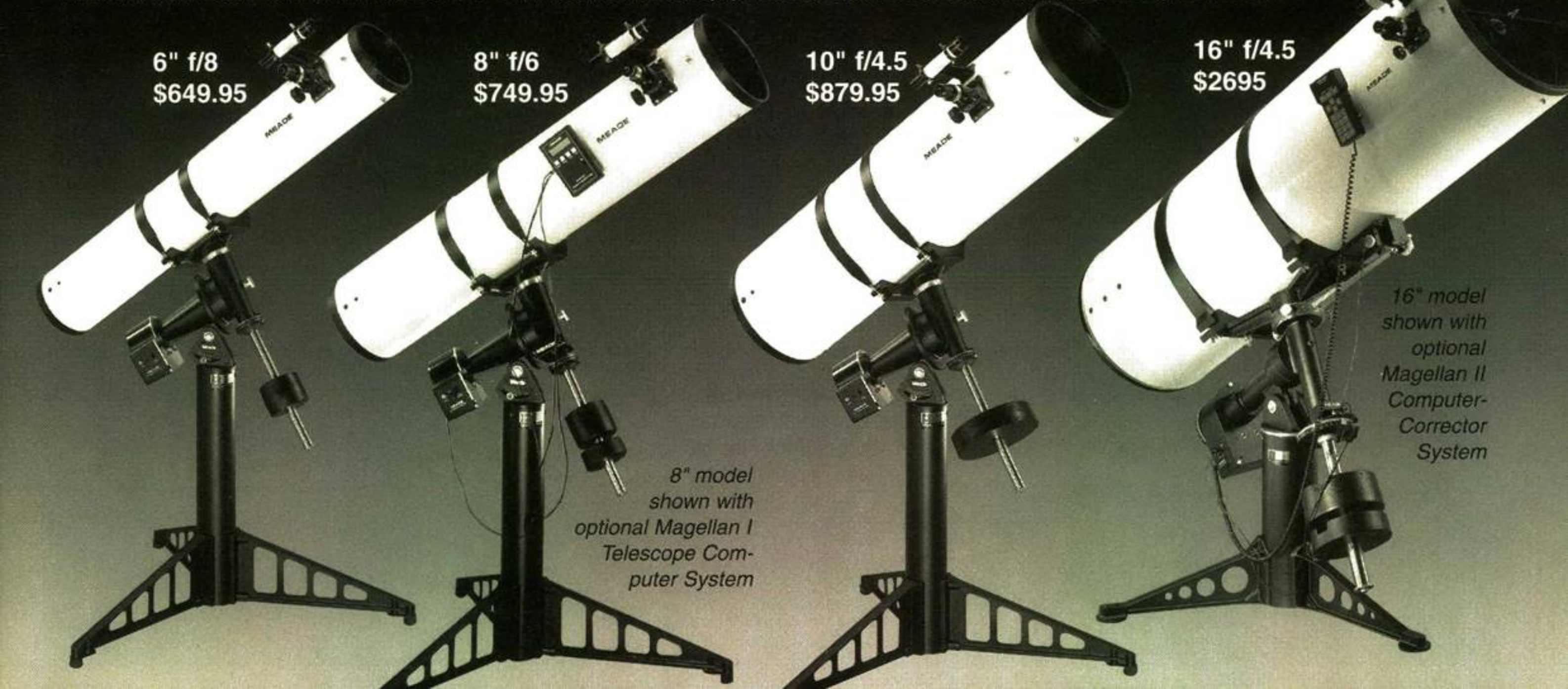
STARFINDER EQUATORIAL TELESCOPES *Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.*



6" f/8
$649.95

8" f/6
$749.95

10" f/4.5
$879.95

16" f/4.5
$2695

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

RESEARCH-GRADE ACCESSORIES

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

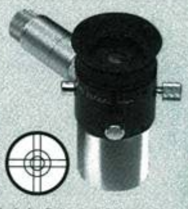
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For all other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

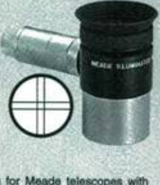
$79.95 (6.85)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

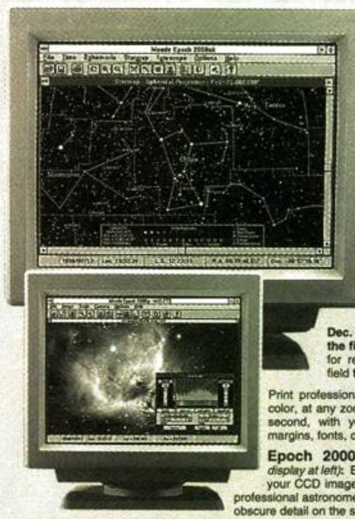
NEW!
MEADE
FLIP-MIRROR SYSTEM
MEADE

#644

MEADE
FLIP-MIRROR SYSTEM

#647

MEADE
FLIP-MIRROR SYSTEM



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left):* Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . **$199**

f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX®

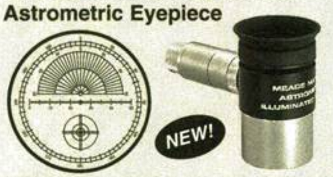
NEW!
MEADE
8 x 25

Permits comfortable right-angle viewing. Replaces standard-equipment ETX finder in seconds, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of any 90mm ETX model and rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tubes for either 1250mm (f/14) or 1450mm (f/16). Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



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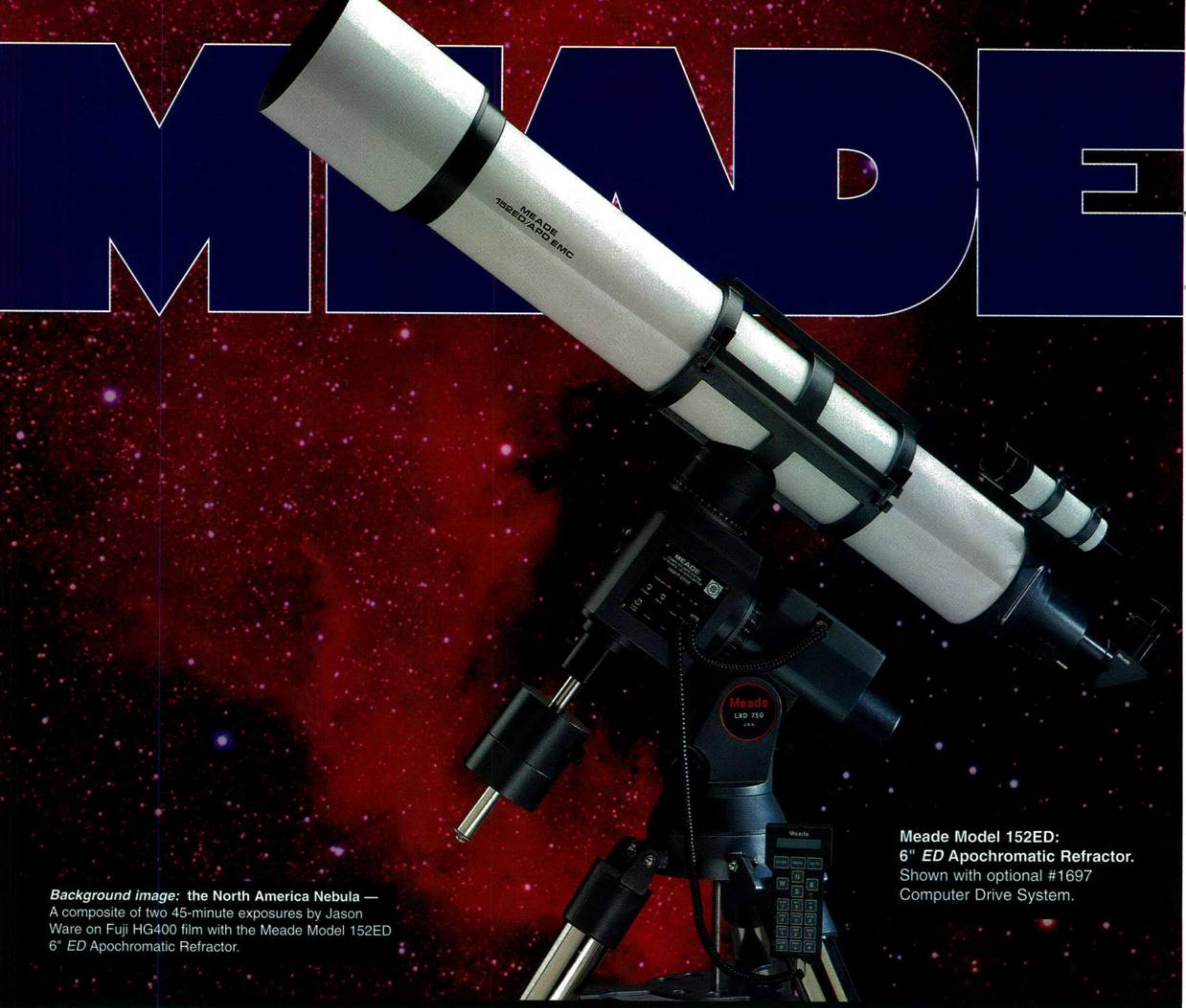

Meade Model 152ED: 6" *ED* Apochromatic Refractor. Shown with optional #1697 Computer Drive System.

Background image: **the North America Nebula —** A composite of two 45-minute exposures by Jason Ware on Fuji HG400 film with the Meade Model 152ED 6" *ED* Apochromatic Refractor.

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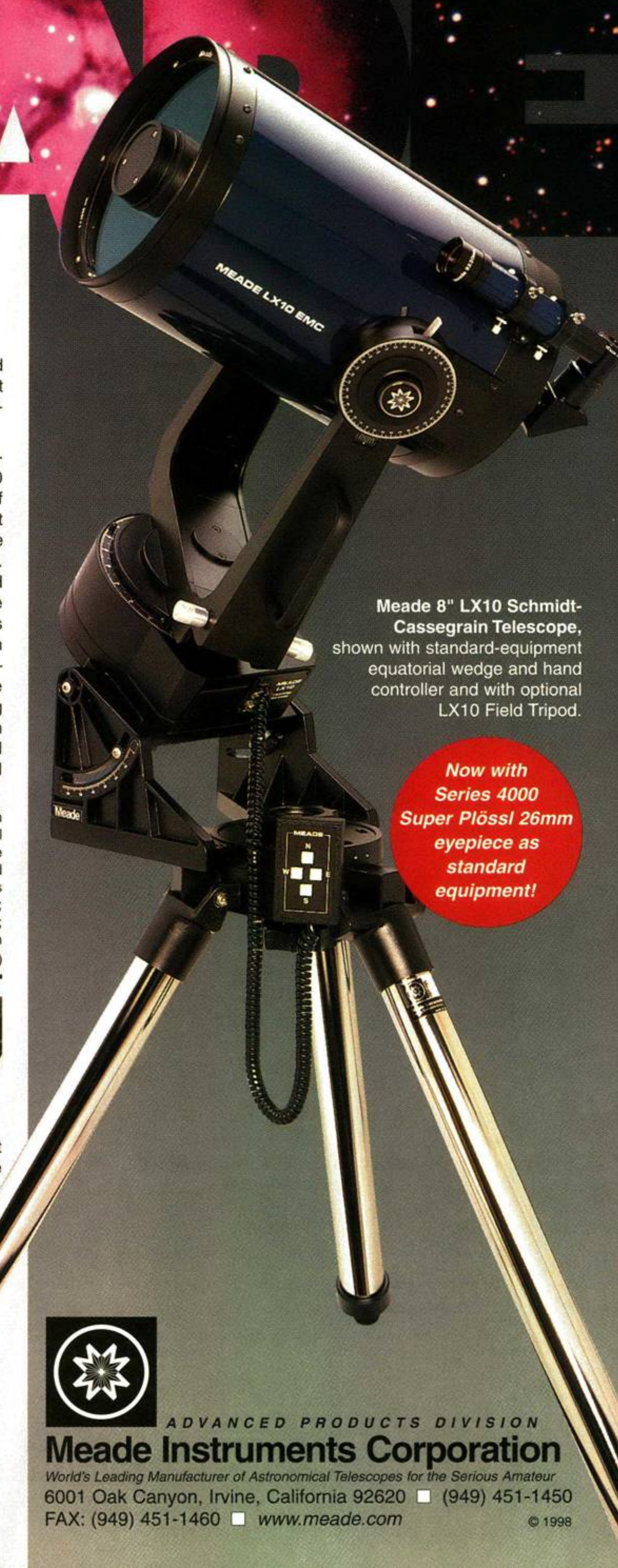

Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

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Water, Water (Almost) Everywhere

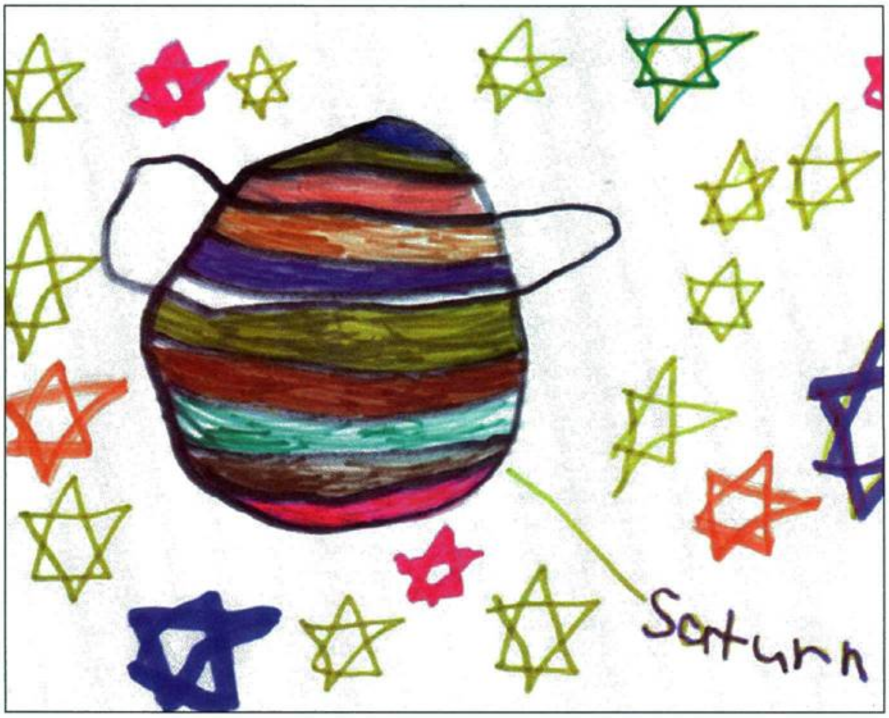
In April's AstroNews, we were told that water was found to be plentiful in star-forming clouds. Theory is that water plays a critical role in helping these clouds to form stars.

The article states: "As a cloud begins to collapse under gravity, it heats up. But long before stars could form, the outward pressure from the warming gas would balance the inward pull of gravity, stopping the collapse. That's where water comes in. Collisions between molecules in the cloud excite electrons in the water molecules, which radiate away that energy. The radiation — what SWAS (Submillimeter Wave Astronomy Satellite) sees — helps cool the cloud and allows the collapse to continue."

The promblem is: If water is crucial in the formation of stars in these clouds, how would the first stars have formed since no water was available? — *Jim Carlisle, San Luis Obispo, California*

Astronomers don't know for sure how the universe made its first stars, but they do have a reasonably good guess. (As you can imagine, there's no way to observe the formation of the first generation of stars, so all the work is based on theoretical considerations.) The best scenario has molecular hydrogen playing the role of the cooling agent. If the clouds from which stars formed were some four to five times denser in the early universe than they are today, then enough collisions between hydrogen atoms would have taken place to create a lot of molecular hydrogen. The big question is: Were the first galaxies that much denser? Obviously the overall density of the universe was much higher back in the early days, but no one knows whether the star-forming clouds were this much denser.

Most astronomers would say that the fact that stars do exist tells us that the density was higher back then, because otherwise there would be no stars. The contributions of other molecules, such as lithium hydride, would likely have been too little to have much effect. Nowadays, of course, nature has found a simpler, easier way to cool the clouds (with water), so that's what she uses.— Richard Talcott, Astronomy *Associate Editor*



David Nosko

Portrait of Saturn on a star field by seven-year-old David Nosko.

Saturn Emerging

Here is a picture done by my son David, seven, depicting Saturn surrounded by a myriad of stars. David, his little brother Dylan, and I have marveled at the sixth planet from the sun through my 10-inch SCT during some pretty inclement weather up here in Canada. When I asked David about submitting a picture to your magazine, he had absolutely no trouble deciding what to draw. I was enjoying your February issue when I came across your Kids' Corner and thought it might be fun to send you an example of a little corner of our universe as seen through the eyes of a youngster. — *Dale Nosko, Edmonton, Alberta, Canada*

Entertaining the Astronomers

I read "Astronomy as Entertainment" and "Planetary Oracles" in Astronomy's April issue. Carl Pilcher's comments about the relationship between entertainment and science captured my interest. After some thought, I went to *Webster's New World Dictionary*. There I found the definition of "entertaining" to be "interesting, pleasurable, diverting, and amusing." *Webster* shows the word amusing to be a synonym. I of course raced to the *A*s to see what was written about amusing. I found the definition to be "to stare fixedly, to keep pleasantly or enjoyably occupied or interested."

While we all associate humorous to both words (as does *Webster*), I have certainly been entertained by science

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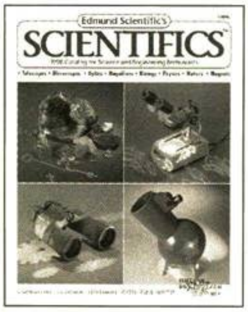
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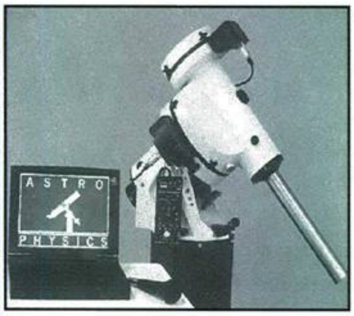

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for as long as I can remember. My neighbors associate humor with me and my pursuit of science, especially after finding me lying on my back in the driveway one cold winter night, wearing my wife's pink earmuffs, a lab coat over several layers of clothing, and fingerless leather biker riding gloves, while looking through binoculars for Messier objects.

Most of the children and many adults of the neighborhood gather in my yard when I get out the telescope. The telescope is entertaining (interesting, pleasurable), educational, and we all find it amusing (staring fixedly through the eyepiece). The conversation resulting from these viewing sessions has been stimulating, even for the children.

I believe if the entertaining side of science were presented more often (without detracting from the subject matter with a big nose, hair, and oversized shoes), children would be more comfortable with the concepts. This would leave more people capable of expanding the horizons we have found for ourselves. — *Steven D. Miller, Keller, Texas*

If I want entertainment I'll go to the movies. If I want politics I'll subscribe to the *New York Times*. You have the best astronomy magazine on the market; don't overthink the plumbing. Add more AstroNews. Publish more amateur and Hubble photos. — *Joe Telfer, Vestal, New York*

Correction

In *Astronomy*'s March issue, "Mile-High Astronomy" describes an outdoor lab course for high schoolers that includes telescope observing. The writer mistakenly claimed the lab students were from the Denver Public School System, but they were actually students of Jefferson County Public Schools, in the Denver area. ■

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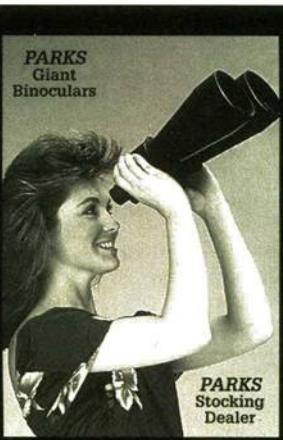
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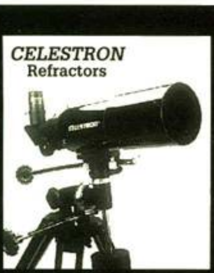
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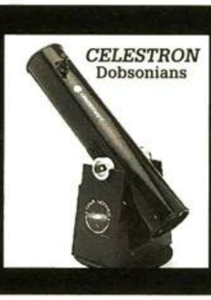
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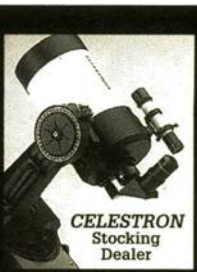
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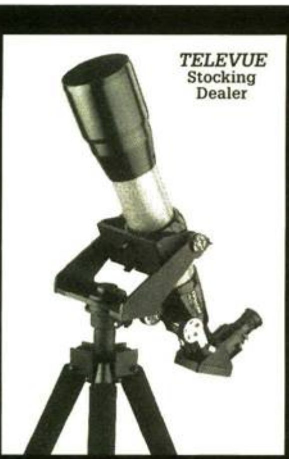
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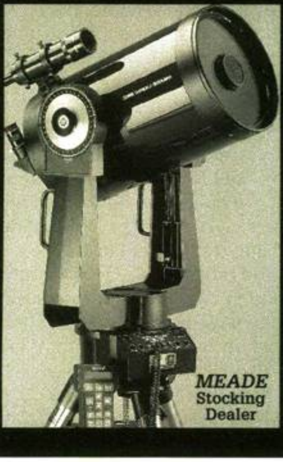
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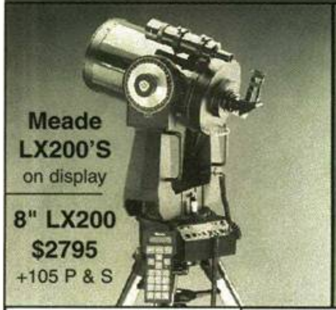
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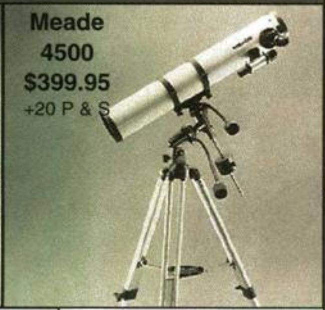

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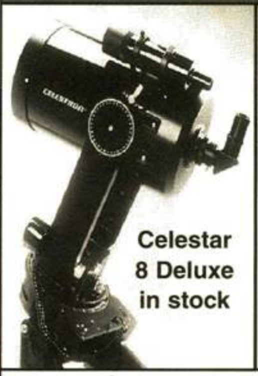
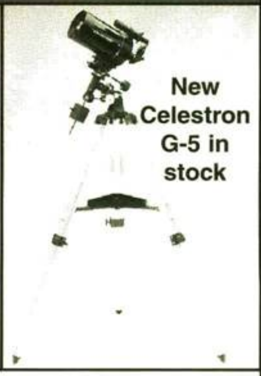


Celestar 8 Deluxe in stock



New Celestron G-5 in stock

Most Celestron Products in stock!

- Celestron star hopper Dobsonians
- Celestar 8 SCT's
- C4.5, FS, 60, 80 + 114
- Ultima series Eyepieces
- LED flash lights
- F 6.3 reducer

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Anyone can sell you a telescope.

Authorized Meade Dealer

Meade ETX-90/EC
$595
#497 Autostar computer
$149

Hardly a day goes by that we don't get a note or E-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. So and so on the East Coast advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!" One of our customers added, "If I wanted that kind of abuse, I would have called my ex-wife."

If you want the right telescope, you need more than a camera store clerk with a price list, a surly attitude, and a wild guess.

What you *really* need are people who will take the time to listen to what *you* need, people with years of experience using and selling telescopes, people who can help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***.

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy scopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. We don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs *. . . and your budget . . .* from the many Meade, Celestron, TeleVue, Takahashi, and Questar telescopes we stock at discount prices from $119 to $27,995. (We had 534 scopes *in stock* as we wrote this.)

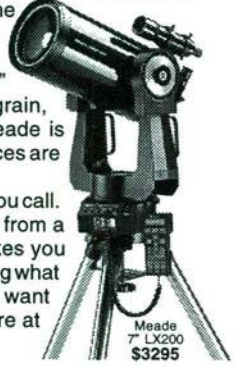
astronomics. No hard sell. No guesswork. Just honest advice, the *right* telescope . . . and a good price. Call us at (405) 364-0858 and find out for yourself.

We order Meade telescopes and accessories by the ton . . . literally!

Meade 203SC
$895

The day before this copy was written, we received 305 cartons from Meade – *3¼ tons* of scopes and accessories in one shipment. We don't know of many other dealers – if any – who actually stock Meade products in those quantities . . . no matter what they claim. But we do. Meade scopes, binoculars, eyepieces, filters, Magellan computers, Barlows, off-axis guiders, illuminated reticle eyepieces, counterweights, T-adapters, tele-extenders – we have them all in stock.

It doesn't matter whether the right scope for you is a fully-computerized 8" or 10" **LX200 Schmidt-Cassegrain**; the **LX200 Maksutov-Cassegrain** 7" to the right; any of the 8" or 10" **LX50** SCTs; the new 3.5" **ETX-90/EC** Maksutov with optional go-to computer shown at the top of this page (we had 45 of them in stock as this was written); or the 8" German mount **203SC/500** Schmidt-Cassegrain, shown above left at its new lower price. If Meade is shipping it for a dealer to keep in stock, the chances are good that we *have* it in stock.



Meade 7" LX200
$3295

Meade prices are about the same anywhere you call. So why order a Meade telescope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

We order Celestron by the ton, too!

The day this was written, we received 4816 pounds of Celestron scopes and accessories in one shipment, giving us 287 Celestron scopes in stock for immediate shipment. We don't know of many other dealers – if any – who stock Celestron in those quantities. But we do.

Because we buy in large quantities, we can take advantage of special buys – like the three scopes shown to the right.

A very moving story.

Our telescope business has more than doubled in the last three years. We outgrew our present location about two years ago. To store the increased inventory that we carry, we're building a new office and warehouse building that's over twice the size of our present location. Sometimes this month, we'll be moving into this larger facility.

Because of the amount of inventory and office equipment we have to move, and the complexity of our phone system and computer network, our move is going to take more than a week to complete. There may be a day or two during the move when our phone system, fax, and/or e-mail will be down.

If you try to contact us and can't get through, we haven't gone out of business. We're just moving. Please try back again the following day.

And a very moving story about Celestron prices.

As mentioned above, we'll be moving shortly to our new offices and warehouse. Faced with the prospect of moving 100 Celestron 8", 11", and 14" scopes, our talented and competent staff said in unison, "What, us pick up that big heavy load of telescopes? You must be out of your mind." Since our whip was out being dry-cleaned, we couldn't reason with them, so we decided to sell the scopes rather than move them.

We truly believe that you won't find a lower price *anywhere* on these three Celestron German equatorial mount Schmidt-Cassegrains – the 8" **G8** with normally optional dual-axis drive corrector, the new 11" **CM1100**, and the new 14" **CM1400**.

Our prices are so low that we had to promise Celestron we wouldn't publish them anywhere. You'll have to call us toll-free at (800) 422-7876 to find out just how much money we'll save you on these great scopes. Quantities are limited at these low, low prices, however.

Celestron 14" CM1400
$???

Celestron 8" G8
$???

Celestron 11" CM1100
$???

CELESTRON

Our free catalog helps you pick the right Meade, Celestron, Questar, Takahashi, or TeleVue scope.

For detailed information on individual products, visit our Web site. Or you can call us at (405) 364-0858, or e-mail us, for your *free* copy of our catalog 99AST. It covers all of the telescopes and accessories we stock – from Apogee, Canon, Celestron, DayStar, JMI, Lumicon, Meade, Optec, Pentax, Questar, Rigel Systems, SBIG, Software Bisque, Takahashi, TeleVue, and more. We'll include our 8-page guide on how to pick the right scope and your discount prices on the 1000+ products we carry. (Sorry, U. S. sales only.) The catalog is yours for only the cost of a one minute telephone call. The information we send will make it the most useful minute you'll ever invest in astronomy.

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Toll-Free Order Line: **(800) 422-7876** Catalogs/Questions/Advice: **(405) 364-0858**

We'll sell you the *right* telescope.

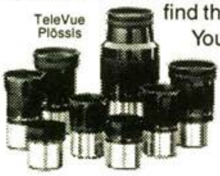
The right scope might be a TeleVue.

TeleVue TV-85 **$1995**

Hardly a week goes by that TeleVue doesn't send us a copy of a new warranty card from one of our customers – to let us read the glowing comments about the TeleVue scope they bought from us. While we're pleased to hear we've satisfied another customer, we've come to expect only praise for TeleVue scopes.

TeleVue's short focal length ultra-premium refractors give you an observing flexibility many other scopes lack. Each scope has the ability to go from very low power wide angle views (as low as 9x in some cases, with a wide 5.7° field) to very high power observing (one test report said they used 89x per inch of aperture on the Ranger, the least expensive TeleVue), all without losing optical quality.

Pronto, **Ranger**, the **TV-85** and **TV-101**, the brass **Renaissance** – all TeleVue refractors are built to the same uncompromisingly high optical and mechanical standards. And the chances are good you'll find them in stock at **astronomics**.


TeleVue Plössls

You'll also find TeleVue eyepieces, Barlows, and accessories in stock at **astronomics**. Nagler, Plössl, Radian, Panoptic, Paracorr, Powermate, Tele-Pod, Gibraltar, Qwik-Point, Starbeam, BinoVue, we carry them all. If it's from TeleVue, chances are good we have it.

The right scope might be a Questar.

Questar 3.5" Standard **$3299**

For many people, the thought of a 3.5" scope that *starts* at $3299 is enough to curl their toes. But for those who want the best small telescope made, $3299 is a bargain.

Solar filters for eyepiece and finder, built-in Barlow, two ultra-premium eyepieces, a velvet-lined hard case, a star chart on the slide-on lens shade with a Moon map beneath – all are standard on a Questar . . . and unavailable from the competition.

Want a Questar, the premier portable telescope? We stock them.

The right CCD camera? It might be from Celestron, Meade, or SBIG.

SBIG ST-8 **$6450**

Meade 208XT **$495**

We stock CCD cameras in depth (we had more than 130 in inventory as this was written). We don't know of any other dealer who stocks CCD cameras in the quantities we do.

From the **Meade 201XT** autoguider at $395 and the **SBIG ST-4** autoguider/imager at $595, to the **Celestron Pixcel 237** at its new lower price of $1199, to the new enhanced blue sensitivity **SBIG ST-8** at $7350, we have the CCD cameras and guiders you want, at prices you can afford.

Plus, we stock CCD accessories – color filter wheels, AC and DC adapters, adaptive optics systems, f/3.3 telecompressors, and more.

Special demo pricing on the SBIG ST-6B and ST-8.

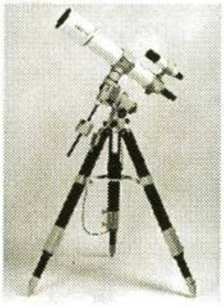
If you want a great deal on a premium quality CCD camera, we have some indistinguishable-from-new SBIG camera demos at prices that will save you up to $750! Each has a full factory warranty.

The latest low dark current version of the industry standard **ST-6B** is regularly $3025. Our special demo price is only $2495.

The **ST-8**, either with or without anti-blooming, is regularly $6450. Our special demo price is only $5700.

Naturally, our demo quantities are *very* limited at these low prices.

Or it might be a Takahashi.


Takahashi FS-102UH (4" f/8 fluorite/SD on EM-10USD mount)

While many people swear *at* the long delivery times quoted by some manufacturers of premium refractors, most knowledgeable astronomers swear *by* the uncompromised optical quality and fast delivery of the Takahashi refractors we keep in stock.

From the 3.1" **FS-78** to the 5" **FS-128**, we stock Takahashi fluorite/special dispersion glass apochromatic doublet refractors, mounts, and accessories – so we can deliver scopes *fast*. Why wait for up to a year to observe through an apo refractor from another manufacturer? You can be usually be viewing through a truly fine Takahashi apo only a few short days after you order from us. We stock complete Takahashi scopes on USD mounts with dual-axis 50x sidereal slewing, as well as apochromatic optical tubes only to install on your own mount.

Also available from stock is the unique Takahashi **CN-212H** 8.3" reflector that converts from an f/12.4 classical Cassegrain reflector to a very fast f/3.9 Newtonian for visual observing and astrophotography.

If you want something bigger, 6" doublet and triplet apo optical tubes and complete scopes are available on a special order basis.

If you want an apo, and want it now, it's Takahashi from **astronomics**.

Or it might be a Bushnell.

Bushnell Voyager 4 **$249**

For most people, Bushnell means binoculars and small "department store special" telescopes. But Bushnell is making a major effort to get into serious astronomical observing with their new line of reflectors.

The **4.5" f/3.5 Voyager**, right, has two 1.25" eyepieces (16x and 100x), a true rack and pinion focuser instead of rubber roller focusing, a carrying strap, a tripod-adaptable altazimuth tabletop cradle mount, and a price that's much lower than the competition.

Bushnell Voyager 6 **$319**

BUSHNELL

The **6" f/8 Voyager Dobsonian**, shown to the left, has an *all-metal tube*, a 25mm eyepiece, 6 x 30mm finder, and is priced at **only $319**.

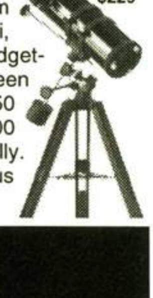
The **8" f/6 Voyager Dobsonian**, similar in appearance to the 6" Bushnell to the left, also has an *all-metal tube*, a 25mm eyepiece, and a 6 x 30mm finder. It's priced at **only $419**.

```
Just wanted to take advantage of the convenience of E-Mail
to let you know how highly I think of your company.  Over
the years, you have delivered excellent service and quality
products . . . a combination that most companies only aspire
to.  As a result, you are one of a select few companies for
the amateur astronomer I will ever refer other people to.
Wishing you continued success.
```

Customer Quote of the Month #86

Dozens of economy scopes for the star-gazer on a budget!

Celestron Tabletop 76 **$119**


Celestron FS114S **$229**

While we're known for carrying premium optics – from Questar, TeleVue, Takahashi, and more – not all of our scopes are budget-busters. We have seven scopes priced between $119 and $249, another fourteen between $250 and $499, and twenty-one more between $500 and $999. All are surprisingly good optically. All are shown in our free catalog. Call us at (405) 364-0858 for your copy.

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Features, Performance, and Value That Eclipse the Competition

SkyView™ Deluxe 6" EQ Newtonian

Meet the new "gold standard" for value in the 6" equatorial reflector class. At its heart is a high-precision 6"-diameter **parabolic** primary mirror – not a lesser-performing spherical mirror as you get with some competitive 6" Newtonians. Rolled steel optical tube. Focal length 750mm (f/5).

Was $599 **NOW $529**

SkyView™ Deluxe 4.5" EQ Newtonian

An exquisite combination of form, function, and affordability for the serious beginning astronomer. The rolled steel optical tube houses a precision-polished 4.5" primary mirror of 900mm focal length (f/7.9).

Was $459 **NOW $388**

SkyView™ Deluxe 90mm EQ Refractor

Exceptionally crisp views of the Moon, planets, and beyond! Multi-coated 90mm achromatic objective lens of 1000mm focal length (f/11.1). Seamless aluminum optical tube.

Was $549 **NOW $488**

Outfit your SkyView Deluxe with an AccuTrack™ DC Motor Drive for automatic star tracking.

$99

ORION
Motor Drive Compatible!

New Lower Prices! Now you can go Deluxe for even less!

Look What's Included

- *New heavy-duty EQ mount*
- *Built-in polar-alignment scope*
  *****A $49 value, FREE*****
- *TWO 1.25" Plössl eyepieces*
- *6x30 achromatic finder scope*
- *Moon filter (1.25")*
- *Gold-anodized aluminum tripod*

ORION
Where The Stars Are

FREE CD-ROM

with any Orion® astronomical telescope!

An $89 Value

The perfect guide to the sky for new telescope owners!

Requires PC running Windows 98, 95, or 3.1x operating system.

Orion ShortTube™ 80mm Rich-Field Refractor

The Perfect Solar Eclipse Scope!

Rich-field 400mm f.l., f/5 scope excels for casual observing and prime-focus astrophotography. 6x30 finder, 1.25" rack-and-pinion focuser, 45° erect-image diagonal, and TWO 1.25" Kellner eyepieces. Mounts on a photo tripod or equatorial mount (sold separately). Makes a terrific guide scope, too!

Was ~~$249~~ **NOW $229**

Glass Solar Filter $59.95

New Lower Price!

Orion ShortTube™ 90mm Rich-Field Refractor

New!

We've redefined portability in the 90mm class! Less than 20" long, but packs 27% more light-gathering capability than an 80mm refractor. Its 500mm focal length (f/5.5) provides gorgeous wide-field views. Includes 6x30 finder, TWO 1.25" Kellner eyepieces, 1.25" star diagonal, rack-and-pinion focuser, built-in 1/4"-20 baseplate. Pop it on a sturdy photo tripod or telescope mount.

ONLY $319

AZ-3 Altazimuth Mount	$169
EQ-2 Equatorial Mount	$149

ORION

Deep Space Explorer™ Dobsonians

The Dobs *S&T* called a "best buy" are now an even better value! New rack-and-pinion focuser, four-vane secondary mirror support for more precise collimation, larger handle on the Dobsonian base, and black tube finish. Standard accessories include a 25mm Explorer II eyepiece (1.25") and 5x finder scope.

6" (f/8)	**$359 complete**
8" (f/6)	**$469 complete**

DSEs subject to available stock.

Explorer™ 90mm Altazimuth

New!

On new AZ-3 mount with dual slow-motion controls!

For scenic viewing in daylight or casual evening starwatching, you can't beat it! Nor can you beat its price. Precision 90mm multi-coated achromatic refractor on new AZ-3 altazimuth mount, featuring dual slow-motion cables and adjustable aluminum tripod. Complete with 25mm (36x) and 10mm (91x) Kellner eyepieces (1.25"), 45° correct-image diagonal, 6x30 finder, and accessory tray. Focal length 910mm (f/10).

ONLY $359

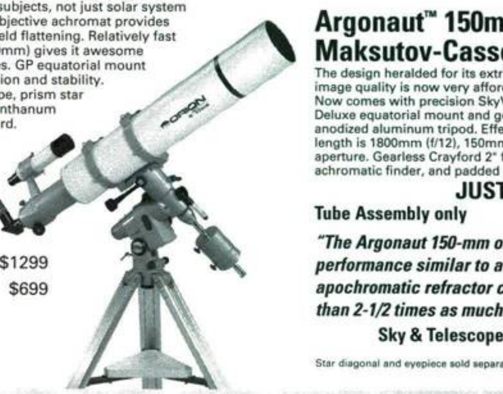
ORION

VX120 GP 120mm (4.7") Refractor

We're breaking out the big gun! The VX120 has enough clear aperture—4.7"—to deliver exceptionally bright, high-definition views of deep-sky subjects, not just solar system fare. Its 4-element, 2-group objective achromat provides added color correction and field flattening. Relatively fast f-ratio of 6.7 (focal length 800mm) gives it awesome astrophotographic capabilities. GP equatorial mount insures high operating precision and stability. R&P focuser, 7x50 finder scope, prism star diagonal, and 20mm (40x) Lanthanum eyepiece (1.25") come standard. Also accepts optional 2" visual back.

JUST $1999

Tube Assembly only	$1299
GP Mount only	$699



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Argonaut™ 6" GP-DX Mak-Newtonian

ORION

High-performance optical design on our most advanced equatorial mount, the GP-DX. Relatively short focal length of 900mm (f/6) provides pleasingly wide views. Central obstruction is a mere 28mm, or 18% of full aperture, for refractor-like image quality. Great for deep-sky or planetary viewing. Pyrex mirrors boast high 93% reflectivity. Crayford 2" focuser and 10x50 finder scope standard. Eyepiece not included. Accepts 2" eyepieces. Motor drives optional.

LOW $1999

Tube Assembly only $1149

"Star images were pinpoints right to the edge of the field.... This is an impressive telescope!"

Sky & Telescope (4/99)

Argonaut™ 150mm EQ Maksutov-Cassegrain

ORION

The design heralded for its extraordinary image quality is now very affordable. Now comes with precision SkyView Deluxe equatorial mount and gold-anodized aluminum tripod. Effective focal length is 1800mm (f/12), 150mm (nearly 6") aperture. Gearless Crayford 2" focuser, 7x35 achromatic finder, and padded case for OTA.

JUST $1099

Tube Assembly only $899

"The Argonaut 150-mm offers ... visual performance similar to a 4-inch apochromatic refractor costing more than 2-1/2 times as much."

Sky & Telescope (4/99)

Star diagonal and eyepiece sold separately.

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Enjoy hand-held, high-power binocular viewing without shaky images! Special microprocessor-controlled prisms provide rock-steady views. You'll see fainter objects and much more detail. S&T raved: "The price and proven performance of the Canon binoculars will certainly make them a hot item for amateur astronomers." Fully multi-coated optics, tack-sharp images edge to edge.

New Lower Prices!

10x30 IS	12x36 IS	15x45 IS
Field of view 6.0°.	Field of view 5.6°.	Field of view 4.5°.
~~$599~~ $548	~~$949~~ $899	$1399

ORION

80mm Binocular Telescope

INTERCHANGEABLE EYEPIECES!

An unforgettable visual experience! Uses interchangeable 1.25" telescope eyepieces, allowing wide range of powers! Includes two 25mm eyepieces (36x, 1.1° field). Mount/tripod sold separately. $899

Custom D Altaz Mount/Tripod
Shown here. $469

Altaz Fork Mount with Cradle $599

SKY & TELESCOPE HOT 25 PRODUCTS 1999

Fork-Mounted 125mm Binocular Telescopes

ORION

New! *VARIABLE-POWER MODEL*

The most powerful truly portable binocular you can buy! Whopping 4.9" multi-coated front lenses of 625mm focal length (f/5). High-power images so bright, sharp, and resolved they'll knock your socks off! Rigid altazimuth fork mount features friction control on both axes, and allows pointing to zenith. Adjustable aluminum tripod. Weighs 24 lbs.

20x125 BT
Fixed 20x power, nice 3.0° field of view, 20mm eye relief. $3795

Variable-Power BT ***New!***
Four fixed powers: 25x, 38x, 50x, and 75x! Field of view 1.6° at 25x, 0.8° at 75x. $4195

ORION

Little Giant™ II 70mm Binocular

More compact than the original Little Giants, and now three different powers to choose from—up to 20x! Big 70mm objectives reveal a plethora of nebulous clouds and stellar clusterings. Great for twilight and daytime use too. Sharp, fully multi-coated optics with BAK-4 prisms and centered lenses. Large, knurled center focus wheel. Classic black coarse-grain finish provides a sure grip. Tripod L-adapter, case, and deluxe wide neck strap included. Made in Japan.

11x70 Little Giant II	15x70 Little Giant II	20x70 Little Giant II
Field of view 4.5°	Field of view 4.0°	Field of view 3.0°
$259	$259	$259

ORION

New Lower Price!

UltraView™ 50mm

Best Bino Available For Eyeglass Wearers

Extra-long 22mm eye relief and unique pop-down eyeguards. Fully multi-coated. BAK-4 prisms. Tripod adaptable.

7x50, 10x50 WA ~~$179~~ $169

ORION

Mini Giant™

Large Apertures in Compact Bodies

Great astro binoculars! Fully multi-coated optics, BAK-4 prisms. Long 18mm eye relief. Tripod adaptable.

8x56	$159
9x63	$189

ORION

New Lower Price!

Giant 80mm

Enjoy stunning resolution. Fully multi-coated optics with BAK-4 prisms. Objective bridge for added rigidity. Center focus. Tripod L-adapter included.

11x80 Giant 4.5° field, 16mm eye relief
16x80 Giant 3.5° field, 16mm eye relief
20x80 Giant 3.5° field, 15mm eye relief
~~$399~~ $379

ORION

SuperGiant™ 100mm

Gigantic 100mm (almost 4") lenses for unbelievably detailed views of the heavens! Fully multi-coated optics with BAK-4 prisms. Platform-type mounting plate included.

14x100 SuperGiant
Individual focus. 3.3° field, 14mm eye relief. $1249

25x100 SuperGiant
Center focus. 2.6° field, 10mm eye relief. $1249

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Sirius™ Plössl Eyepieces
You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. Fully-coated optics, rubber eyeguards.

1.25"
6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm $49.95 each
32mm, 40mm $59.95 each

.965"
6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm $49.95 each

Ultrascopic™ Eyepieces
The highest contrast and light transmission obtainable. Superior 5- or 7-element design with Ultra Multi-Coatings on every surface. Wide 52° apparent field. Removable winged rubber eyeguard. Threaded for filters. 1.25" barrels.
3.8mm, 5mm, 7.5mm, 10mm, 15mm, 20mm, 25mm, 30mm, 35mm
From $79

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Attractively priced for even limited budgets. Their 3- and 4-element fully coated glass lens configurations provide a 50° apparent field of view. Threaded for filters.
1.25"
6mm, 10mm, 13mm, 17mm, 25mm
$33.50 each
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6mm, 10mm, 13mm, 17mm, 25mm
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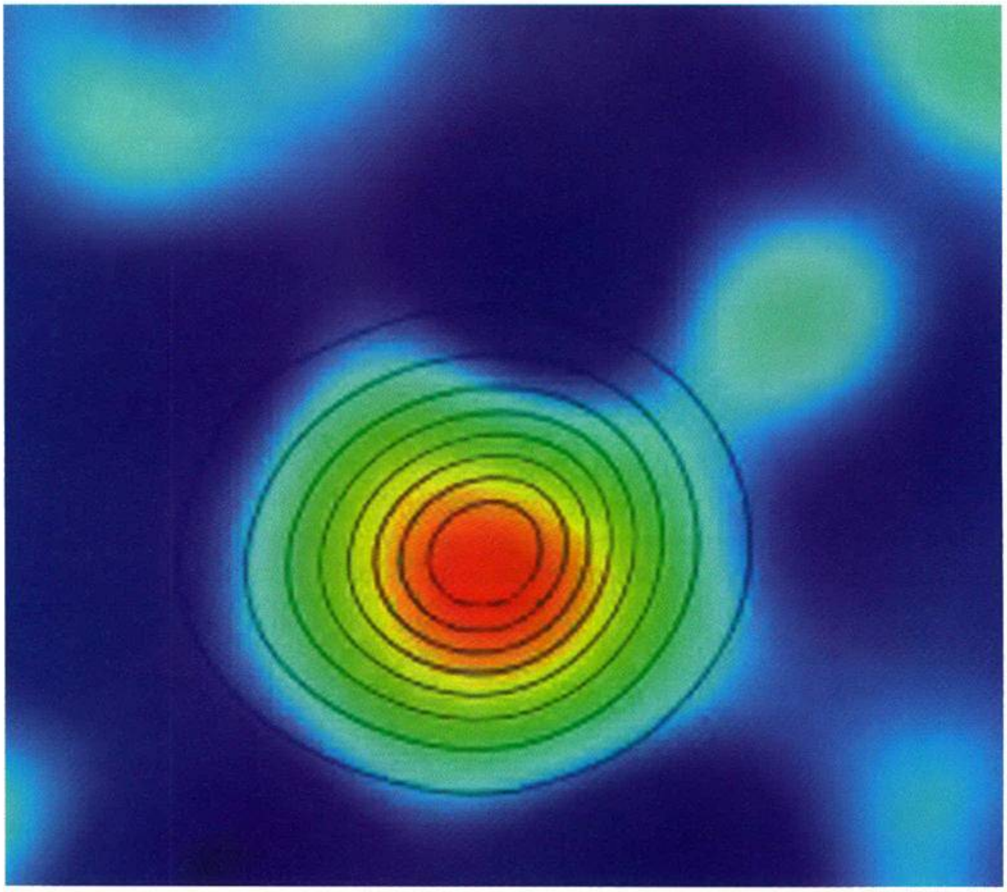

Top: An x-ray map of the sky around the galaxy cluster Abell 2218 reveals hot gas (red) that scatters cosmic microwave background radiation (CMBR) electrons to other frequencies. The "radio hole" created by this scattering is represented by the contour lines that show levels of decreasing intensity in the CMBR. (J. Carlstrom/M. Joy/BIMA/ROSAT) **Left: The visual image of Abell 2218 is a small area at the center of the radio hole.** (Warrick Couch/STScI)

▶ The Chandra X-ray Observatory is poised to give astronomers a novel way to determine the age of the universe after the observatory's scheduled launch aboard Space Shuttle Columbia in July. Marshall Joy, an x-ray astronomer with the Marshall Space Flight Center in Huntsville, Alabama, and his colleague, University of Chicago radio astronomer John Carlstrom, plan to combine Chandra's x-ray data with ground-based radio images to make precise estimates of the distances to several galaxy clusters.

Joy and Carlstrom plan to make use of the Sunyaev-Zeldovich effect to obtain their distance estimates. The effect is a slight distortion of the cosmic microwave background radiation (CMBR) resulting from the scattering of microwave photons as they pass through the hot x-ray-emitting gas of galaxy clusters. When the microwave photons — remnants of the Big Bang — pass through such clusters, many of them collide with electrons in the cluster's hot gas. The colliding photons either gain or lose energy and thus are "scattered" to frequencies outside the CMBR. The net effect is a slight decrease — typically only 0.05 percent — in the microwave-background intensity.

"Doubling the density of the cluster gas will simply double the magnitude of the Sunyaev-Zeldovich effect, but it will roughly quadruple the x-ray emission," says Joy. He explains that the radio measurements of the Sunyaev-Zeldovich effect, when combined with x-ray brightness of the clusters' hot gases, will allow him and Carlstrom to make estimates of the distance to the galaxy clusters.

Once the distance to galaxy clusters is estimated, the rate at which the clusters' component galaxies are moving away from Earth can be determined. That number is used to ascertain the expansion rate of the universe and its approximate age.
— Andrea Gianopoulos

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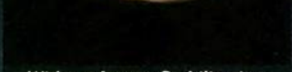
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SPACE DEBRIS

Satellite Terminator Ready for Testing

► Earth has roughly 8,000 pieces of orbiting space junk, including everything from paint chips to abandoned satellites. The debris whizzes overhead at 5 miles (8 km) a second like supersonic shrapnel. A single piece could damage or doom the Space Shuttle, the International Space Station, and defense and telecommunications satellites.

Left unchecked, the waste will increase with planned future launches of hundreds of satellites — some with lifetimes as brief as five years. However, a Seattle, Washington, firm has figured out how to keep those satellites from adding to Earth's orbiting refuse heap.

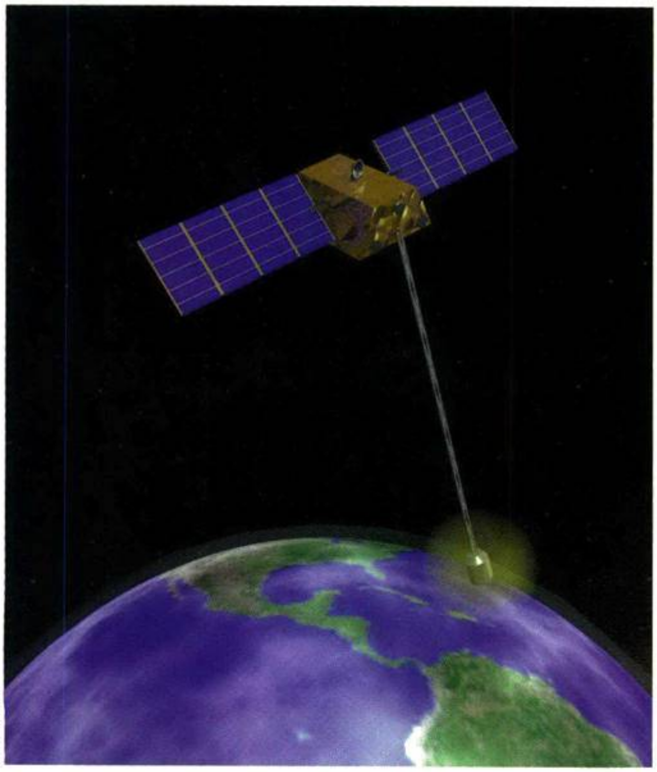
NASA's guidelines include limiting the orbiting debris. The agency stipulates that future satellites should quickly re-enter Earth's atmosphere to burn up after they have completed their missions.

Tethers Unlimited Inc. President Robert Hoyt calls his company's solution the "Terminator Tether." An aluminum-wire tether about 6 millimeters thick and three miles long would be deployed from satellites when they are no longer able to function. The movement of the metal wire through the magnetosphere would generate an electric current and act like a brake. The rapid decrease in the satellite's orbital velocity would allow it to descend toward Earth and burn up in the atmosphere in a matter of weeks instead of hundreds or thousands of years without such a device.

The company will test its device on a Russian-built upper stage rocket in 2000. Hoyt expects a tether to cost about $250,000.

The Terminator Tether was one of 125 contracts selected for Phase II in NASA's three-phase Small Business Innovation Research Program. NASA budgets about $100 million a year to "provide increased opportunities for small businesses to participate in federal research and development." A diverse group of ideas won Phase II approval, including a frozen-dessert system, a soil probe for Mars, an icing-detection radar, and a rock driller.

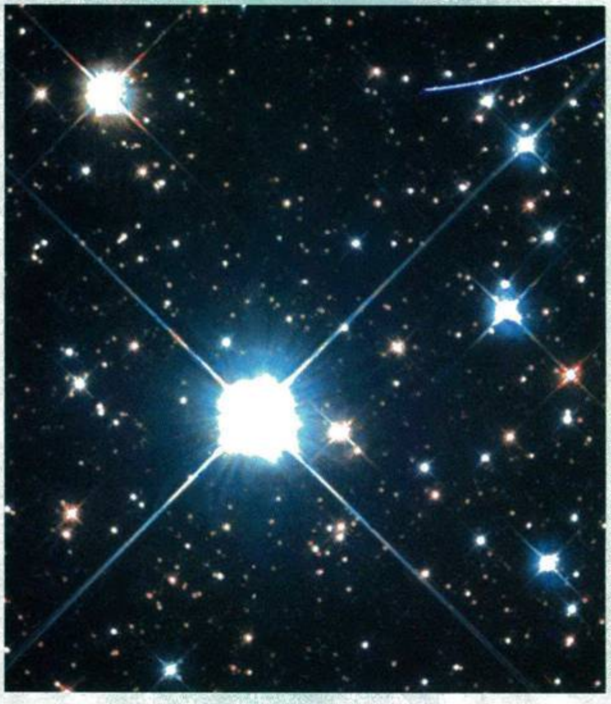
— Kelly Whitt



This artist's conception of the Terminator Tether includes a tail-like appendage several miles long. The drag of the tether could pull satellites out of orbit.

Robert Hoyt

HUBBLE HERITAGE



Hubble Heritage Team (AURA/STScI/NASA)

A STAR-RICH FIELD in Centaurus partially masks the blue arc of an uncatalogued asteroid, which was photographed by the Hubble Space Telescope's Wide Field and Planetary Camera 2 on April 6, 1994. While studying the motion of Proxima Centauri, Edward J. Groth of Princeton University captured the solar system interloper floating in front of stars that are millions of times more distant. This and about a hundred other interlopers have been found by JPL astronomers Robin Evans and Karl Stapelfeldt, who have systematically searched the HST archive for these nearby objects. They are so small and faint that astronomers can't yet determine their orbits.

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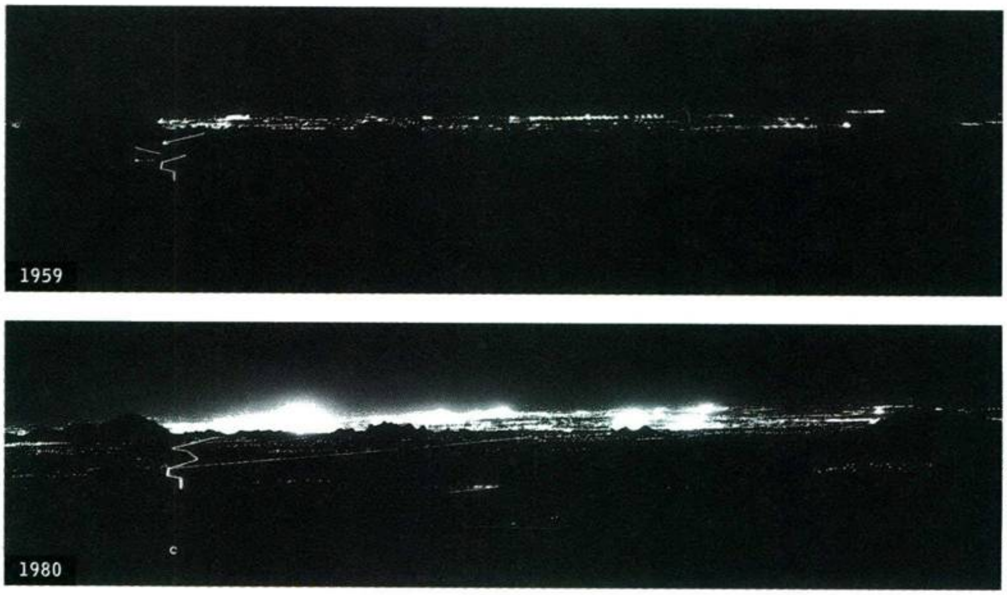
LIGHT POLLUTION

Development Threatens Arizona's Night Skies



International Dark-Sky Association

These photographs, taken from Kitt Peak, document the increase in Tucson's light pollution as the city's population has grown.

▶ Astronomers recently won a battle against a Tucson development plan that threatened to produce unacceptable light pollution near an Arizona observatory. It was a rare victory for dark skies, but one that could be overturned in the coming years.

On January 12, the Pima County Board of Supervisors turned down a rezoning request by developer Fairfield Homes to build 6,100 new homes about 30 miles south of Tucson. The rural site is near Mount Hopkins and the Fred L. Whipple Observatory. It was the first time in 25 years the county board had turned down such a request.

Even with stringent lighting-fixture controls, the Canoa Ranch development would have polluted the night sky with electric lighting. On January 6, Whipple astronomers called for help, and astronomers from 29 countries signed electronic petitions opposing the development. Astronomers presented the petitions to the board of supervisors.

However, local constituencies have the most political power in southern Arizona, and Jim Nintzel, a Tucson journalist who covers growth issues for *Tucson Weekly*, says astronomers should not celebrate yet. He says that the Canoa Ranch proposal was doomed for a number of reasons, not the least of which was a lack of expertise by Fairfield Homes in winning over the supervisors. The developer also failed to build local support for the project before trying to win the zoning-change vote. Railroad, farming, and mining interests also opposed the development and formed a rare coalition with environmentalists and the astronomers.

Fairfield Homes reacted by threatening the astronomers with a lawsuit if they didn't rescind their opposition. "What a blunder. They admitted that was a big mistake," says Nintzel. On the night of the supervisors' vote, 1,000 people attended the meeting, many speaking for or against the development. However, Nintzel says the outcome had already been decided.

"I think the plan was doomed before the meeting started. Too many of these board members (three of five) had campaigned on environmental issues," he says. He adds that Fairfield Homes has taken a new approach. After the vote, it assured farming and mining representatives that Canoa Ranch won't deplete water supplies. Next year the developer can request another zoning change, but by then dark-sky advocates may face a more difficult battle to stop the development. — Tony Ortega

VERY LARGE TELESCOPE

Sharpest Image Yet from VLT

▶ Astronomers justly acclaim the skies above the Andes Mountains of northern Chile as among the clearest in the world, offering superb views of the universe. During the predawn darkness of March 5, the European Southern Observatory's Very Large Telescope (VLT) on Cerro Paranal captured its sharpest image yet.

Using the 8.2-meter Unit Telescope 1, the first of four identical telescopes that will join to make the VLT the largest in the world, researchers targeted the spiral galaxy NGC 2997 in the southern constellation Antlia. A five-minute exposure in the near-infrared part of the spectrum showed features 0.25 arcsecond in size. That resolution is about four times better than possible at other ground observatories and it approaches the 0.1 arcsecond resolution of the Hubble Space Telescope.

Astronomers then combined the near-infrared image with a three-minute green exposure and a three-minute red exposure, both with slightly lower resolution, to produce a dramatic color image of the spiral galaxy. Details as small as 70 light-years across are resolved in the galaxy, which lies approximately 55 million light-years from Earth. Many bright, star-forming regions dot the spiral arms and the odd, twisted spiral arm that extends along the image's right edge.

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European Southern Observatory

Bright regions of star formation and dark lanes of dust occupy the spiral arms of galaxy NGC 2997.

The first week of March proved doubly rewarding to the European astronomers at Cerro Paranal. Not only did they snare the sharpest view yet through Unit Telescope 1, but Unit Telescope 2 saw its first light. The second of the VLT's four telescopes captured light from a bright star, showing that the scope's optics also seem to be in good shape. After technicians adjust its optical and mechanical systems, the telescope should soon deliver some "astronomical" images.
— Richard Talcott

SEARCHING FOR ET

SETI Shifts from Radio to Lasers

▶ After nearly 40 fruitless years of searching for radio chatter from alien civilizations, astronomers are trying a new approach.

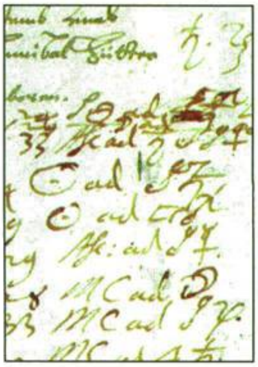
Three new programs with the Search for Extraterrestrial Intelligence (SETI) Institute are looking for laser signals beamed our way. The new search strategy is called optical SETI.

Charles Townes and Robert Schwartz first suggested in 1961 that technologically advanced civilizations might use lasers, beams of coherent electromagnetic radiation, for interstellar communication. Townes shared the 1964 Nobel Prize in physics with two Soviet Union physicists for his role in the development of lasers. Townes and Schwartz realized that laser signals in visible or near-infrared light could contain vastly more information than radio signals. In addition, high-energy laser beams could be targeted to maximize their efficient transmission through space.

But the laser idea languished for four decades as the SETI community focused almost exclusively on radio searches. "SETI has been too narrowly focused on a single strategy," says University of California at Berkeley astronomer Dan

400-year-old Kepler Manuscript Found

Anthony Misch, a support astronomer at Lick Observatory and a German-speaking book collector, says he immediately recognized the significance of an unremarkable six- by eight-inch framed paper. "As I looked the document over my hand was shaking," says Misch. "I knew right away this had potential to be a pretty spectacular discovery." He was researching solar-eclipse expeditions in the library archives at the University of California in Santa Cruz when he spotted the manuscript. It apparently is a horoscope penned in the late 1500s or early 1600s by 16th-century astronomer Johannes Kepler. For the complete story, go to http://www.astronomy.com/horizon.html.



University of California at Santa Cruz

This Kepler manuscript is a horoscope for an Austrian nobleman.

Could Venus Reveal Earth's Fate?

University of Colorado astronomers Mark Bullock and David Grinspoon are recreating the evolution of the Venusian atmosphere with computer models. Today, Venus is 900° F with a carbon dioxide atmosphere enclosed in dense sulfuric-acid clouds. "Volcanism must have been active within the past 30 million years to support the thick clouds observed today," says Grinspoon. He and Bullock think the planet's volcanoes are likely still active. For the complete story, go to http://www.astronomy.com/horizon.html.

Space Robots Get Artificial Muscles

NASA's space rovers are beefing up with artificial muscles in order to explore the asteroid 4660 Nereus.

Typical robotic arms use gears, hydraulics, and other expensive, heavy parts, but the new robotic muscle tissue is a highly flexible plastic called electroactive polymers that flex and contract when electric currents are applied to them. "Electroactive polymers are changing the paradigm about the complexity of robots," says robot-muscle innovator Yoseph Bar-Cohen. "In the future, we see the potential to build simple robots that dig and operate cooperatively like ants, that can soft-land like cats, or that can travel long distances like a grasshopper." For the complete story, go to http://www.astronomy.com/horizon.html.

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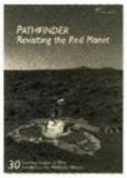

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Werthimer, who leads one of the three new optical SETI programs. "It's very hard to predict what another civilization is going to do."

Werthimer's group plans to observe 2,500 nearby stars with a 30-inch telescope at the Leuschner Observatory near Berkeley, California. The team has developed sophisticated but low-cost electronics and light detectors to catch pulses of laser light as brief as 1 nanosecond (one-billionth of a second). Civilizations with technology similar to ours could generate such pulses, which could be detected from distances of thousands of light-years.

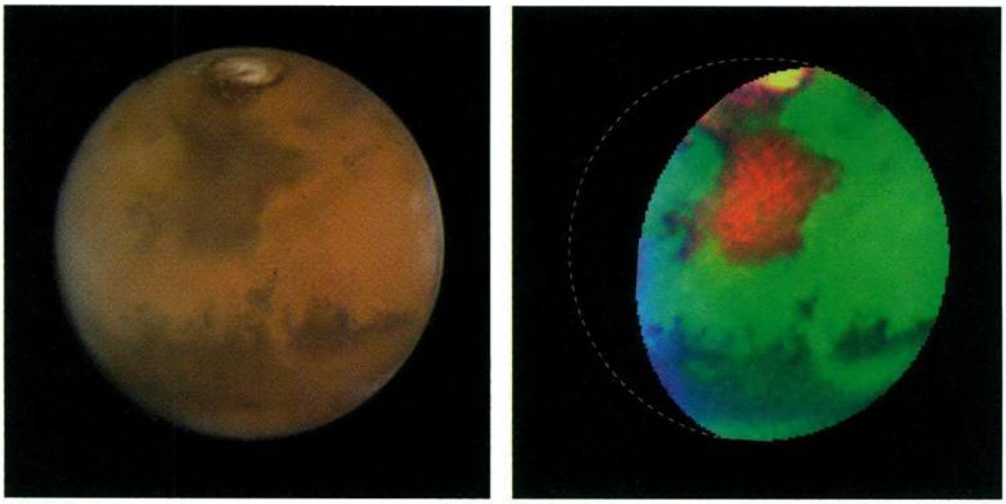
Using similar electronics, Harvard University physicist Paul Horowitz leads another group looking for laser pulses. Horowitz's team analyzes the stray light from a Harvard project that looks for stellar binary companions. The team uses the 61-inch telescope at the Oak Ridge Observatory in Harvard, Massachusetts.

The scientists collaborating on an optical SETI program at the Oak Ridge Observatory in Harvard, Massachusetts include, left to right, Robert Stefanik, Joe Zajac, Costas Papaliolios, Chip Coldwell, and Jonathan Wolff.

Paul Horowitz/Harvard University

San Francisco State University astronomer Geoff Marcy leads the third group. Marcy has co-discovered 12 extrasolar planets. Graduate student Amy Reines is developing software to detect sharp peaks of laser light in the spectra of 900 solar-type stars collected in the planet-search effort.

"I'm very pleased that people are picking up interest in optical SETI and that it's going to be seriously undertaken," says Townes. "I think it will continue to grow because the logic and the numbers are there. I hope somebody picks up a signal." — Robert Naeye



Malin Space Science Systems, NASA, and Nature

Hubble Space Telescope images capture the same hemisphere of Mars in visible light (left) and infrared light (right). The false-color infrared image reveals a reddish region containing water-bearing minerals.

MOIST MARS

Wet Minerals in Martian Sand

▶ A newly released Hubble Space Telescope image of Mars adds further evidence that the Red Planet was once wet. Hubble's infrared camera took the image, which picked up the signature of water-bearing minerals in a region of Mars's northern hemisphere known as Acidalia Planitia.

Specific compounds can't be identified from the image, but they likely are types of water-containing minerals. "Clays and hydroxides are potential storehouses for water. They could help us get at the question of what happened to Mars's water," says planetary scientist Jim Bell of Cornell University. "I think it is significant that the potential water-bearing minerals are found in a region where the geology suggests that massive floods once coursed across the martian terrain."

The imaging team, led by Bell, color coded the water-containing signature as red. The observations must be made from space because the infrared radiation is blocked by molecules in Earth's atmosphere.

Mars Global Surveyor (MGS), which carries an infrared spectrometer, is now mapping Mars, including Acidalia Planitia. "The MGS spectrometer will get much higher resolution and will be able to observe more wavelengths, so we're hoping it can confirm and extend this result," says Bell.

MGS 's high-resolution camera has made its own recent discovery: a new type of martian sand dune. The dunes are much smaller and brighter than dunes in photos taken by the Viking orbiters. These bright sand dunes seen by the MGS are only a few dozen feet across and several hundred yards long — surprisingly similar to many dunes found in Earth's deserts.

Scientists don't know what the dunes are made of, but sulfates have bright colors and are known to exist in Mars's soil. Earth's deserts also have sulfate sand dunes. Peter Thomas of Cornell University, lead author of a paper in the February 18 *Nature*, says the dunes could be made of gypsum (hydrous calcium sulfate), which is used in plaster of paris.

CM TELESCOPES

Unequaled optical excellence combined with a superb new German equatorial mount. The mount and telescopes are manufactured by Celestron in Torrance, California.

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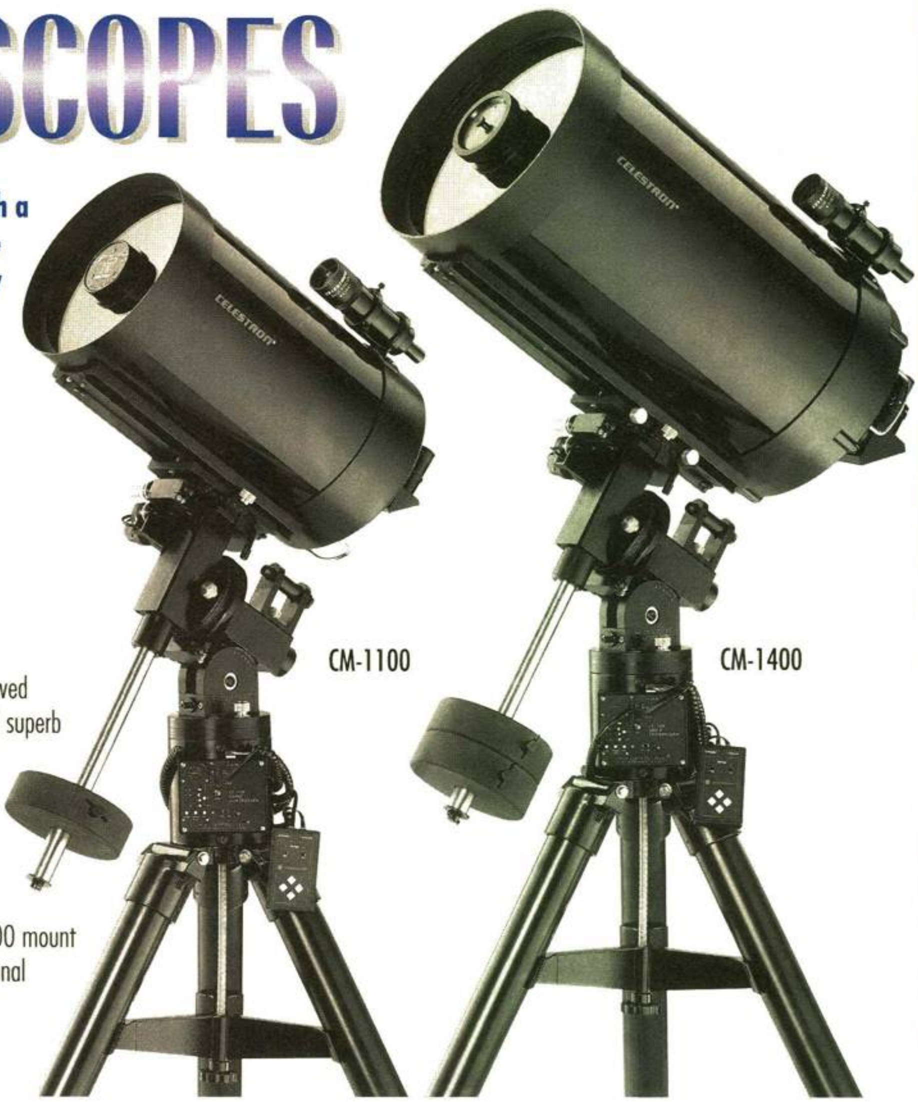
Astrophotography and CCD imaging possibilities are endless. The 11" has been an astrophotography standard. Now the 11" and 14" coupled with the CI-700 mount raise the standards even higher. The 14" with the optional Fastar optics allows many ***unguided*** images at f/2!



THE CI-700 MOUNT

also sold separately for medium and large aperture telescopes.

- Manual slow motion controls in both axes
- Preloaded bearings in both axes for smooth axis rotation and gear mesh
- 1" solid centerless ground shafts in both axes for higher payload capacity
- 180 tooth main gear (5.625" dia.) allows for longer unguided exposures
- ½" dia. precision 303 stainless steel worm gears for super accurate drive accuracy
- Large laser engraved setting circles – 5.25"
- Dual support fixed height tripod for maximum rigidity
- Machined aluminum and stainless steel
- 22# counterweight (44# with CM-1400)
- Built-in polar axis finderscope is standard
- All these technical features deliver the smoothness, precision, refinement and controllability that you've always wanted in a fine mount.

DUAL-AXIS DC ELECTRONICS

- PEC (Periodic Error Correction)
- BC (Backlash Compensation) in declination
- Sidereal, solar, lunar, and King tracking rates
- .3x and .5x guiding rates
- 8x, 16x and 20x setting rates
- Hand controller operates simultaneously with all SBIG CCD imaging systems
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- Optional Advanced Astro Master® adapts easily with the specially designed hardware kit to computerize the telescope
- Standard accessories include: 9x50 finderscope, star diagonal and 26mm Plössl eyepiece.

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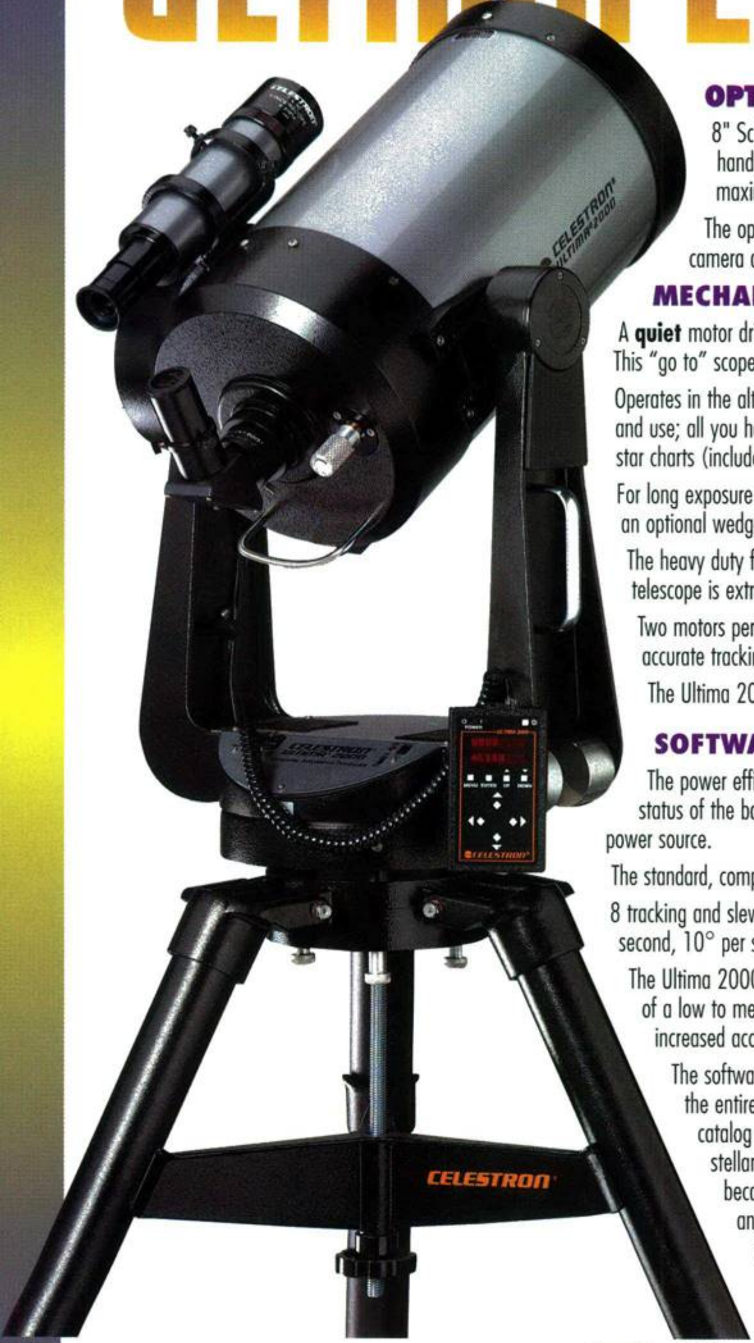

OPTICS

8" Schmidt-Cassegrain Telescope, 2032mm Focal Length, f/10. Each optical system is individually hand figured and guaranteed to be diffraction limited. Multi-coated Starbright® coatings group for maximum light transmission and bright, high contrast images.

The optics are Fastar compatible which provides the potential for CCD imaging using the PixCel CCD camera at an incredible f/1.95! Deep sky images in 30 seconds or less.

MECHANICAL FEATURES

A **quiet** motor driven "go to" computerized telescope built entirely at the Celestron factory in Torrance, California. This "go to" scope won't disturb your neighbors.

Operates in the altazimuth configuration allowing you to find most objects in seconds. Simple to set up and use; all you have to do is find two alignment stars which are easily located on the laminated monthly star charts (included).

For long exposure astrophotography or CCD imaging, use the telescope in the equatorial configuration by adding an optional wedge.

The heavy duty fork mount is extremely rigid and sits on top of a sturdy, adjustable metal tripod. Yet, the telescope is extremely portable and convenient to take with you.

Two motors per axis are standard as well as precision worm gears in both axes that provide very smooth, accurate tracking ability.

The Ultima 2000 can be moved manually (by hand) without losing its star alignment.

SOFTWARE/ELECTRONICS FEATURES

The power efficient DC telescope is operated with the included AA batteries. A built-in voltmeter monitors the status of the batteries. Optional adapters are available to run the telescope from a car battery or from an AC power source.

The standard, compact hand controller operates the various functions such as position, identify, speed, pointing, etc.

8 tracking and slewing speeds are available – sidereal, solar, lunar, King, 2x sidereal, 0.5x sidereal, 2° per second, 10° per second.

The Ultima 2000 has impressive pointing accuracy where the object selected will always be in the field of view of a low to medium power eyepiece. Includes Enhanced Encoder Resolution and Relative Go To mode for increased accuracy which is ideal for centering objects on a CCD chip.

The software database contains over 10,000 deep-sky objects as well as major planets. The objects include the entire Revised New General Catalog, the Messier catalog, selected objects within the IC catalog and the ESO and Uppsula catalogs, 241 interesting double and multiple stars, and 661 non-stellar objects. The database may not be the largest in the industry but it is one of the most useful because of the object selection. In addition, the display of the object data is the most complete of any commercial computerized telescope.

For beginners and educators, a special Tour mode is available which allows you to view 15 popular objects by season, automatically.

To quickly and easily find your favorite objects, the telescope offers 25 user-defined selections.

The Ultima 2000 can by operated by a computer using popular astronomy software such as *The Sky*. Programs can also be written by the user to control the telescope.

Other standard features and accessories include: 9x50 finderscope, multi-coated 26mm Plössl eyepiece – 1¼" (78x), star diagonal – 1¼", LED display, auto guider port, northern and southern hemisphere operation, comprehensive instruction manual.

For more detailed information on this telescope, contact a Celestron dealer or Celestron.
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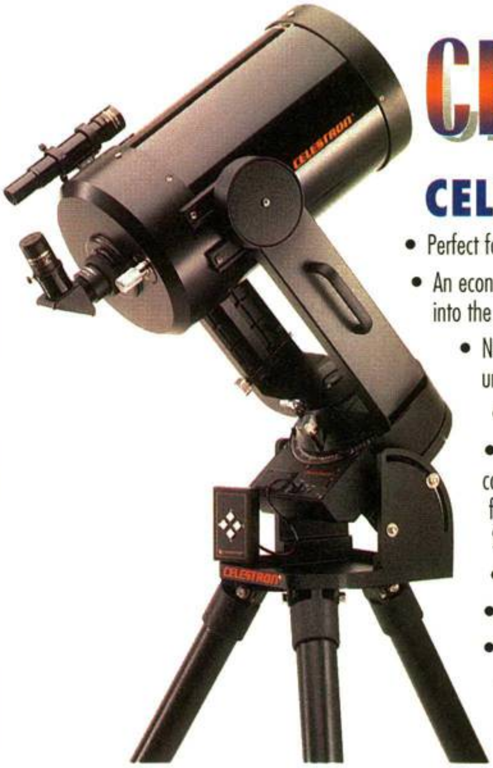
CELESTAR 8 TELESCOPES



CELESTAR 8

- Perfect for a first time astronomer.
- An economical but full featured 8" (2032mm f/10) Schmidt-Cassegrain. A considerable amount of engineering work went into the design of the Celestar 8.
- No sacrifice was made in the optics. Celestron's carefully hand-figured system delivers diffraction-limited optics of unsurpassed quality. Starbright® coatings are standard.
- The energy efficient DC electronics are powered by a 9 volt alkaline battery for easy astronomy on the go.
- The totally cordless electronics have a built-in drive corrector which is activated when using the optional hand control. The R.A. motor's main tracking speed is an accurately regulated sidereal rate. The optional hand control allows for fast and slow override of R.A. tracking speed and ± operation of the optional DEC motor. A comment from the Sky & Telescope review – "the digital electronics delivered a near-perfect sidereal tracking rate."
- The Celestar 8 drive can operate in the Northern or Southern hemisphere from 0° to 90.°
- The unique Wedgpod is a combination tripod and wedge which is very stable.
- Made in the U.S.A.
- Standard accessories include: 6x30 Finderscope, Star Diagonal – 1¼" and a 25mm SMA Eyepiece – 1¼" (81x).
- Weight – 41 pounds.

CELESTAR 8 DELUXE

- For the more serious astronomer.
- This telescope utilizes the same superior optics and has all the features of the Celestar 8, but is enhanced, for those who prefer a premium version.
- This model has a heavier duty fork mount and drive base, with a precision worm gear drive system.
- Superior tracking accuracy is attained with this advanced drive system, which has four tracking rates and PEC (Periodic Error Correction).
- For the kind of versatility that makes observing a pleasure, the hand controller makes available a micro guide rate of .5x sidereal and a slew rate of 8x sidereal.
- The stepper motor drive electronics are cordless and operate on two 9 volt batteries.
- The Celestar 8 Deluxe has many features that are necessary for the more serious amateur astronomer, particularly if you're interested in astrophotography or CCD imaging with the PixCel or other CCD cameras.
- Fastar compatible for f/1.95 CCD imaging – deep sky images in 30 seconds or less!
- Made in the U.S.A.
- The standard accessories for this telescope include: Declination Motor, Car Battery Adapter, Hand Controller, Wedge and a Tripod with adjustable height that's exceptionally rigid and sturdy .
- Also standard is a large 9x50 Finderscope, Star Diagonal – 1¼" and a multi-coated 26mm Plossl Eyepiece – 1¼" (78X).
- Weight – 52 pounds.

ADVANCED ASTRO MASTER®

CELESTRON
Advanced Astro Master

The Celestar 8 Computerized and the Celestar 8 Deluxe Computerized telescopes are the same as the Celestar 8 and Celestar 8 Deluxe but with the addition of a factory installed and tested Advanced Astro Master.®

Its pointing system contains a data base of over 10,000 objects. Once aligned, it will guide you to any one of these objects. Included are the entire RNGC catalog, the Messier catalog, IC catalog (selected objects), major planets, over 241 interesting double and multiple stars and a user definable catalog of 25 objects. Operates on a standard 9V battery.

Contains an RS-232 serial interface to enable usage with programs like "The Sky"™ by Software Bisque.

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LARGE APERTURE

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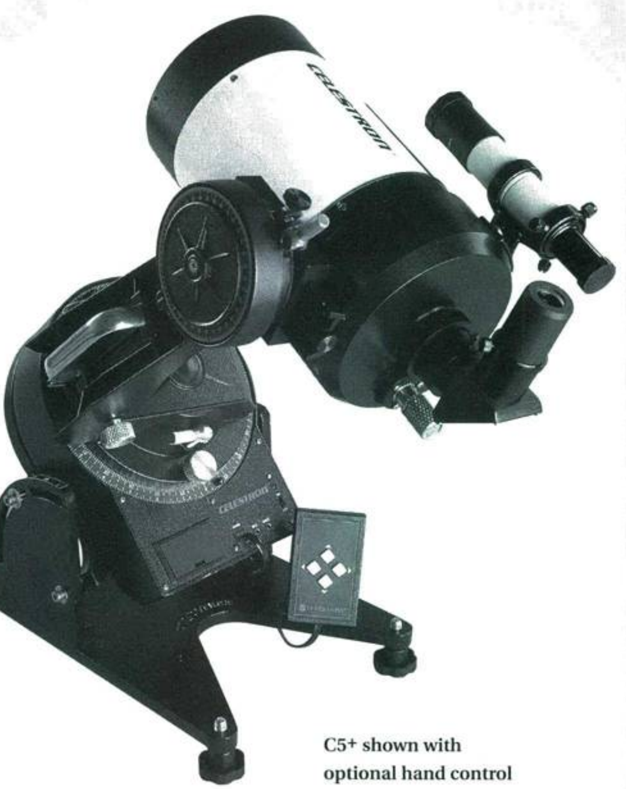
ULTRA PORTABILITY

C5+

- For astronomy on the go, the C5+ can't be beat. Due to its excellent Schmidt-Cassegrain design and careful crafting, this telescope is a serious, high performance instrument, and its compact size makes it totally portable.
- The optical system of the C5+ features Starbright® coatings. An *Astronomy* magazine review said, "the C5 I tested contained superb optics. At high powers, stars exhibited a clearly defined Airy disk surrounded by a bright first diffraction ring and several successively fainter outer rings. This was a telescope that demonstrated how well Schmidt-Cassegrain optics can perform and met Celestron's promise of diffraction limited optics."
- The C5+ features Celestron's legendary hand-figured, diffraction limited optical system for optical performance you can depend on. The reputation for excellence of this telescope is such that it was chosen by NASA, over all other competitive models, for several space shuttle missions.
- The DC electronics of the C5+ have a built-in drive controller, powered by a 9 volt alkaline battery. A comment from the *Sky & Telescope* review — "the digital electronics delivered a near perfect sidereal tracking rate."
- Standard equatorial wedge supplied with the C5+ has a built-in bubble level and is adjustable from 0° to 90°.

STANDARD SPECIFICATIONS:

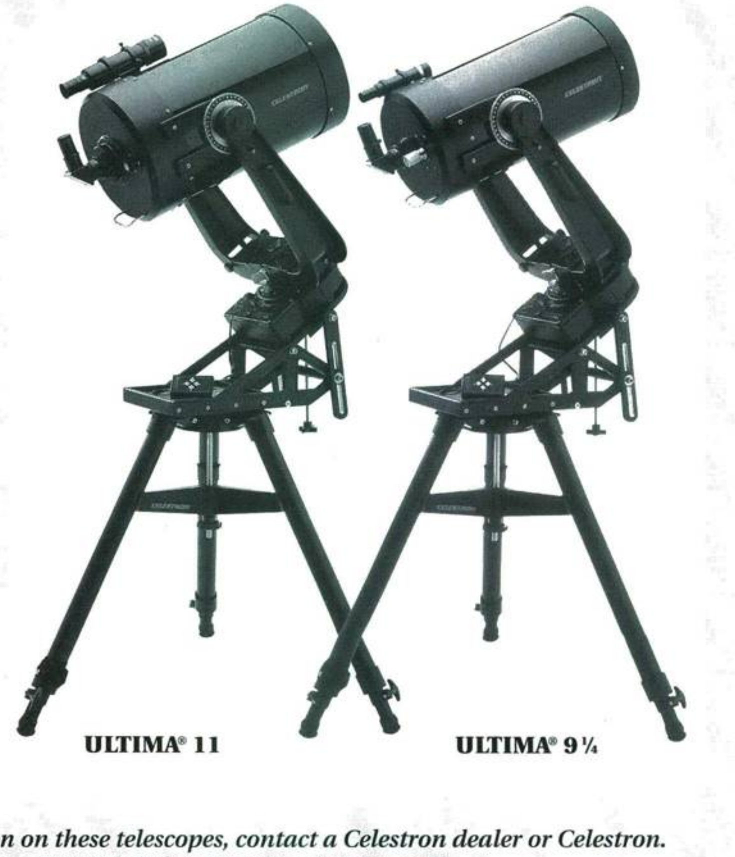
- 5" (127mm) Aperture
- Focal Length of 1250mm
- Focal Ratio of f/10
- Standard 1¼" Accessories Include: 25mm SMA Eyepiece (50x), Star Diagonal, and Visual Back
- 6x30 Finderscope
- Unique Single-Arm Fork Mount with Carrying Handle
- Weight: 23 lbs. (including the wedge)
- Made in the U.S.A.
- The C5+ can even be converted to a computerized telescope with optional accessories.



C5+ shown with
optional hand control

ULTIMA® 9¼ and ULTIMA® 11

- The compact Schmidt-Cassegrain design makes these powerful telescopes portable enough to load in your car and take out to your favorite observing sites. Further, this design is user-friendly, so even a beginner can enjoy using a large telescope.
- The images captured by these versatile telescopes are superb, due to optics designed to perform flawlessly.
- 9¼" (235mm) Aperture, 11" (279mm) Aperture
- 9¼" Focal Length of 2350mm, 11" Focal Length of 2800mm
- Focal Ratio of f/10
- Starbright® Coatings
- 6x30 Finderscope – 9¼", 7x50–11"
- Hand Controller
- Focusing Micrometer on 9¼"
- PEC Electronics
- Ergonomic, user-friendly operation is the trademark of the Ultima® telescopes. The Ultima 9¼ and 11 telescopes were designed with functional use as a top priority, and they deliver.
- Standard 1¼" Accessories Include: 25mm SMA Eyepiece (94x) and Star Diagonal, 26mm Plössl (108x) for 11"
- Adjustable, Rigid Metal Tripod, Heavy Duty Wedge and Deluxe Latitude Adjuster.
- Weight: 74 lbs. for 9¼", 80 lbs for 11"
- Made in the U.S.A.
- The superb optics use high transmission Starbright® coatings to capture the brightest, sharpest images.
- The newly designed fork tines of the mount and drive base are sand cast and they add greater stability.
- The totally cordless DC servo quartz drive system runs on an ordinary 9 volt battery.
- Celestron's optional Advanced Astro Master® can be added to create a computerized telescope.



ULTIMA® 11 **ULTIMA® 9¼**

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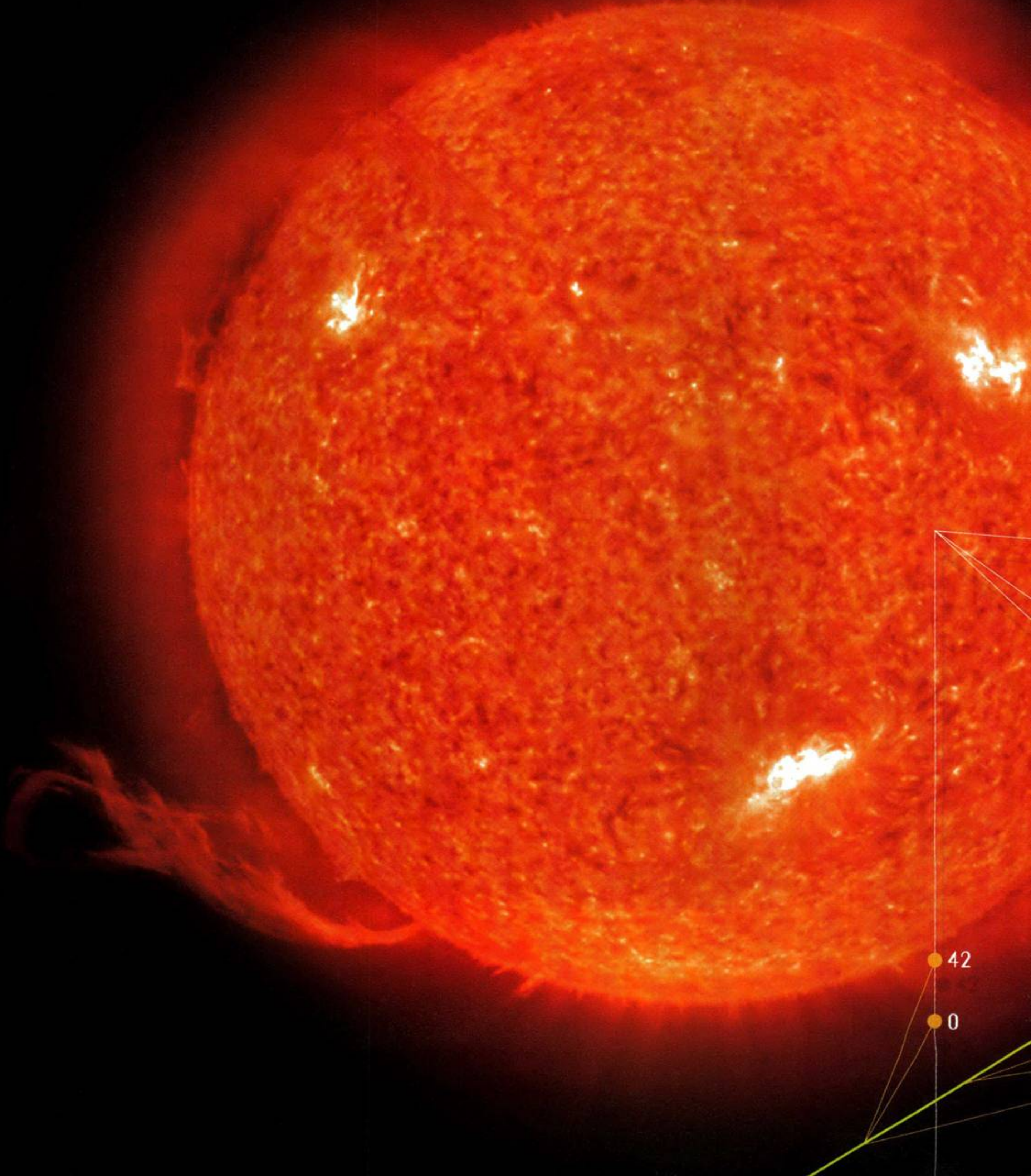
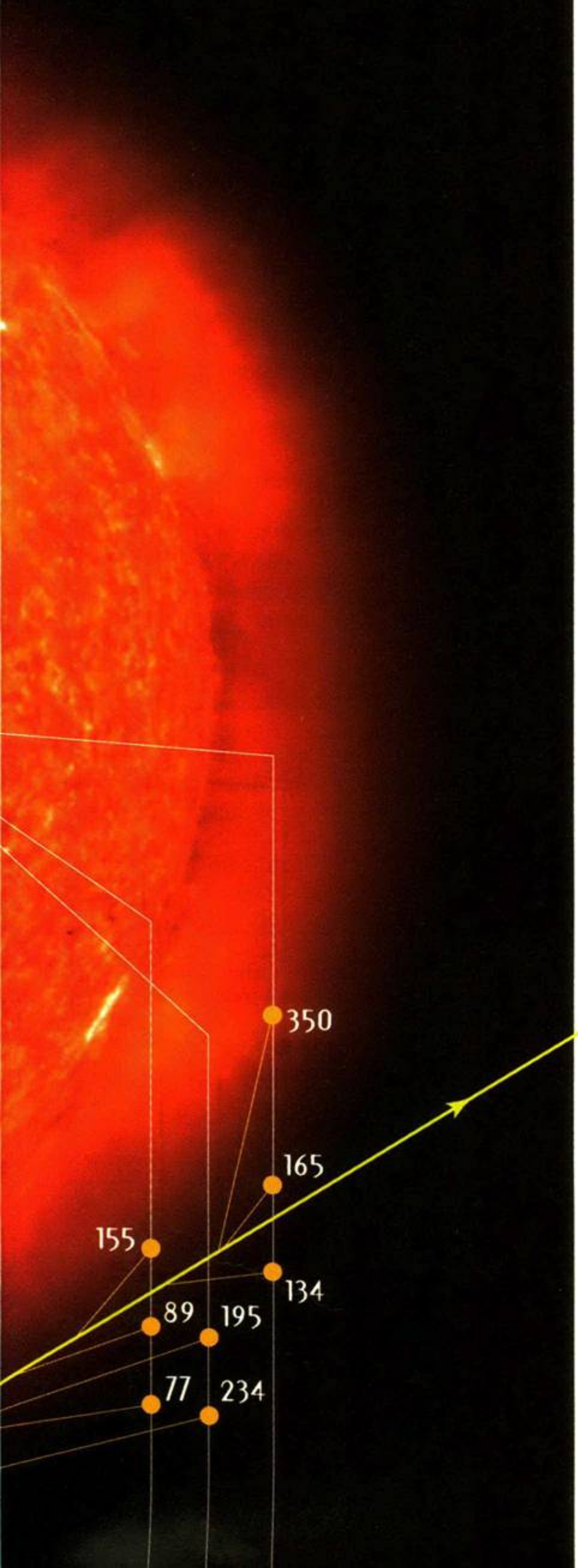
catching co



smic ghosts

Neutrinos can pass through Earth as if it wasn't there, yet they can tell astronomers about the most inaccessible places in the universe.

by Ivan Semeniuk



To a neutrino, the universe is an empty place. Weirdly estranged from other subatomic particles, neutrinos spend their time flying blindly across the cosmos, only rarely interacting with any matter they encounter along the way. In the time it takes you to read this sentence, some 30 trillion neutrinos will pass through the page you are holding, leaving no trace of their existence. Even solid rock is no obstacle; a neutrino can penetrate the full thickness of Earth more easily than a ground ball can slip between two infielders a solar system apart.

Like its better known cousin, the electron, the neutrino appears to be a fundamental particle — one which cannot be divided into even smaller constituents. But unlike the electron, the neutrino carries no electric charge and so is thought to be immune from the forces that can divert electrons and bind them into atoms. The neutrino is also far lighter than the electron, with a mass so minuscule that it has yet to be directly measured; if it has mass at all. Consequently, gravity exerts little if any influence on a neutrino's wanderings.

Virtually unstoppable and all but undetectable, neutrinos would seem to be of little use to astronomy. Yet physicists are developing the tools needed to explore the heavens with neutrinos. The technical challenges are enormous, but the scientific payoff is substantial. Because neutrinos can penetrate almost any barrier, they carry information about some of the most inaccessible places in the universe, from the cores of collapsing stars, to gamma-ray bursts, to the black hole-powered jets of active galaxies.

"Thirty years ago, the words 'neutrino' and 'astronomy' would not have been used in the same sentence," says Rocky Kolb, a theoretical physicist at Fermilab. Now a new generation of neutrino detectors is coming on line, ready to exploit the universe's most exclusive messenger service.

The sun, seen in this image from SOHO's Extreme-ultraviolet Imaging Telescope, is a copious producer of neutrinos. EIT Consortium/NASA/ESA

When a neutrino interacts with an ice molecule under the South Pole, it creates a particle (a muon, seen here as a green line) that emits a burst of light that can be detected by AMANDA's photomultipliers (orange dots).

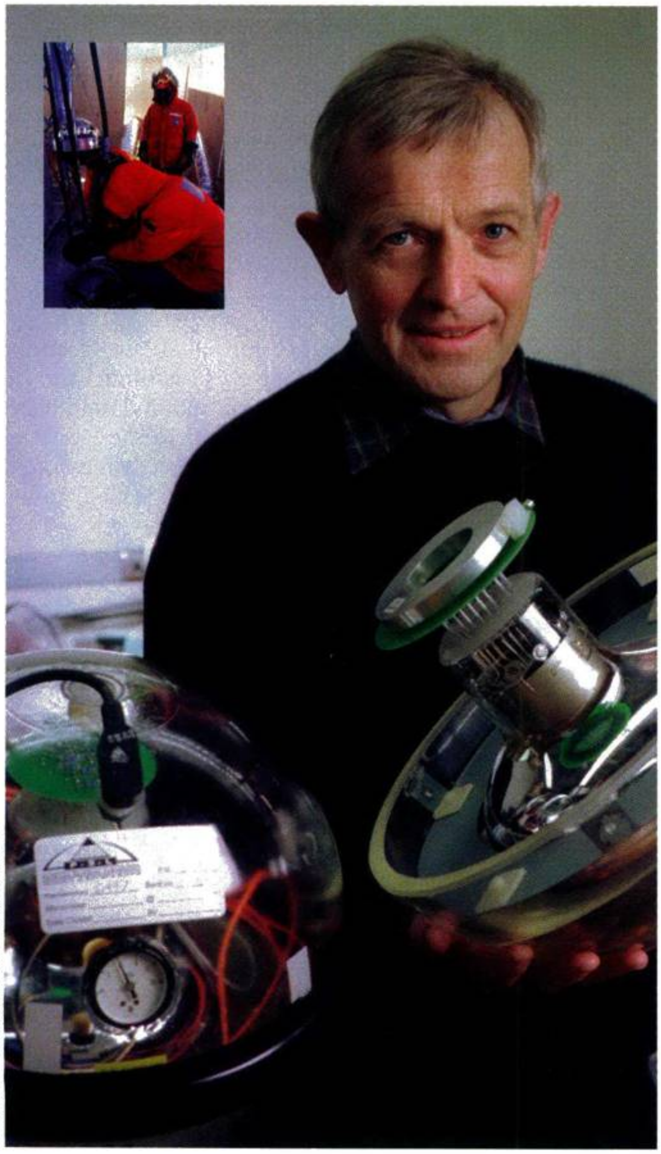
Douglas Lowder (University of California-Berkeley)/AMANDA

solar surprise

It was absence, not presence, that led Wolfgang Pauli to postulate the neutrino. In 1930, the Austrian physicist was trying to explain why a radioactive process known as beta decay sometimes involves the disappearance of a small amount of energy. Pauli hypothesized that an unknown particle was spiriting away the missing energy. Due to the particle's lack of electric charge, it was later dubbed the neutrino, Italian for "little neutral one."

It took another generation to prove that neutrinos exist. Frederick Reines and Clyde Cowan of the Los Alamos Laboratory detected them streaming out of a nuclear reactor in 1956 (Reines, who died in August 1998, shared the 1995 Nobel Prize in physics for this discovery). The find carried important implications for astrophysicists: Calculations predicted that nuclear reactions in the sun's core produce large quantities of neutrinos at a well-defined rate. If these solar neutrinos could be detected and measured, they would provide a direct test for theories of how the sun shines.

In the mid-1960s, Ray Davis of the Brookhaven National Laboratory became the first scientist to set out in pursuit of solar neutrinos. Davis's detector consisted of 100,000 gallons of dry cleaning fluid, rich in the isotope chlorine-37. Occasionally, a passing solar neutrino of sufficient energy will be absorbed by chlorine-37 to produce the slightly heavier isotope argon-37. By carefully monitoring the argon content in his detector, Davis hoped to take the first solar neutrino census.



Jeff Miller/University of Wisconsin Inset: AMANDA

University of Wisconsin physicist Francis Halzen holds half of a photomultiplier tube, which is similar to those being used by the AMANDA Project to detect neutrinos at the South Pole. Inset: Scientists in the AMANDA project drop a string into a 1.5-mile-deep hole in the Antarctic ice cap. Dozens of photomultipliers are attached to the string.

Davis's biggest technical hurdle came from cosmic rays — high-energy particles from space that can also trigger the chlorine-argon reaction. To avoid the problem, Davis set up his neutrino experiment deep underground in the South Dakota Homestake gold mine. The 4,850 feet (1,480 meters) of rock between the detector and Earth's surface was enough to block most cosmic-ray particles and prevent them from swamping the infrequent detection of solar neutrinos.

"Before then, people did astronomy from mountain tops or occasionally from rockets," recalls John Bahcall, a theoretical astrophysicist at the Institute for Advanced Study and one of Davis's chief collaborators. "Nobody did astronomy or particle physics underground, and very few people at the time thought it was a reasonable thing to do."

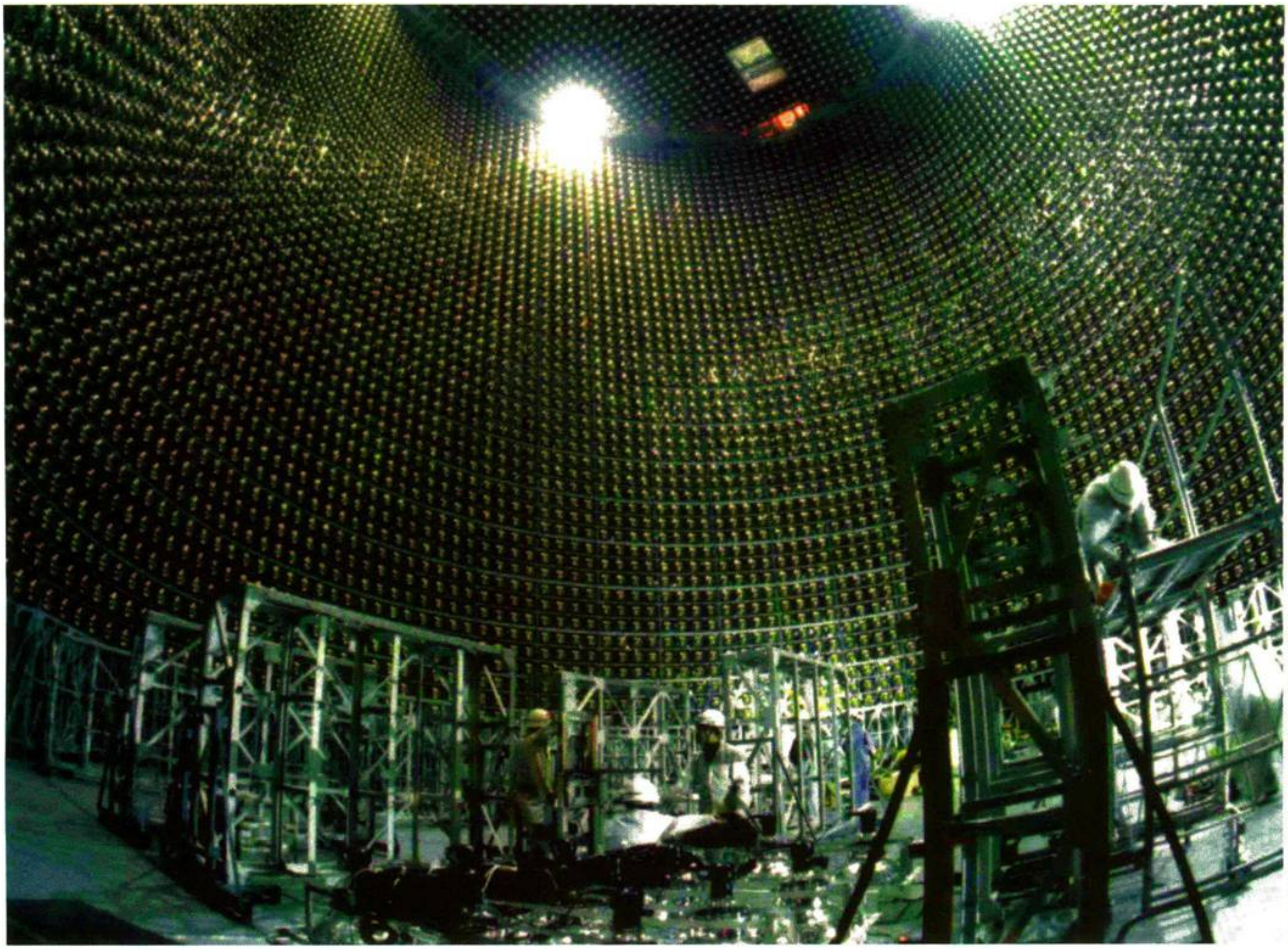
The results of Davis's experiment are now the stuff of science legend. While the cleaning solution proved successful at capturing solar neutrinos, the surprise was how few of them there were to catch — less than half the number predicted by solar models. The results have since been confirmed by other experiments, all of which use different means of detecting neutrinos. No matter how astrophysicists adjust their solar models, it has proven impossible to accommodate the experimental results within standard theory. "There came the understanding that this was a problem that wasn't going to go away," says Bahcall. With astrophysicists confident that their understanding of solar physics was on firm ground, suspicions turned toward the neutrino itself as the source of the problem.

let it sno

For scientists at the Sudbury Neutrino Observatory (SNO), the daily commute to work includes being dropped in a wire-mesh elevator cage more than one mile below ground and then walking the equivalent distance into the heart of a northern Ontario nickel mine. Just before reaching their destination, staff and visitors alike must shed their mine gear, shower, and change into clean clothes, washing and blowing away any traces of radioactive dust. Only then will they be permitted entry into the world's deepest and most sensitive neutrino experiment.

SNO was built to look for evidence that some solar neutrinos change identity after being produced in the sun's core. Particle physicists call it "flavor mixing." Although the term brings to mind a carton of melted Neapolitan ice cream, it actually refers to the fact that neutrinos come in three varieties, or flavors. Electron neutrinos are produced in reactions involving electrons. Muon neutrinos and tau neutrinos are produced in reactions involving the electron's two heavier siblings, the muon and the tau particle.

Even before the solar neutrino problem was discovered, some physicists speculated that neutrinos might oscillate from one flavor to another. But this sleight of hand could only occur if neutrinos differ from one another in mass,



Institute for Cosmic Ray Research, The University of Tokyo

Super-Kamiokande, located in a zinc mine under the Japanese Alps, detects neutrinos as they pass through a 12.5-million-gallon, 10-story-high tank of ultrapure water. Recent experiments at Super-K strongly suggest that neutrinos have mass.

implying that they have mass to begin with. This went against the predictions of the Standard Model, the model developed in the 1970s that lays out the properties of various particles and how they interact with one another.

The neutrino detector built by Ray Davis, and those that followed, were all designed to spot electron neutrinos — the only flavor created in the sun's nuclear furnace. But in 1986, Soviet physicists Stanislaw Mikheyev and Aleksei Smirnov, expanding on work by Lincoln Wolfenstein at Carnegie Mellon University, demonstrated that electron neutrinos might experience a greatly amplified rate of flavor mixing when passing through matter. "Electron neutrinos interact differently in matter," says Wolfenstein, "because matter has electrons in it." In practice, this so-called MSW effect (named after the discoverers' initials) could serve to change large numbers of electron neutrinos into muon neutrinos on their way out from the sun's interior. Once in the vacuum of space, the converted neutrinos would retain their new identities and thus escape detection.

SNO is designed with the MSW effect in mind. At its heart is a 40-foot-wide acrylic sphere filled with 1,000 tons of heavy water. The heavy water is needed because it is rich in deuterium, an isotope of hydrogen. Each deuterium atom contains an extra neutron that can be used to detect neutrinos in two separate reactions. But while the first reaction is triggered only by electron neutrinos, the second can be initiated by neutrinos of any flavor. If the missing solar neutrinos have indeed switched flavor, they should turn up in the second reaction. "Heavy water is really the ideal medium for doing this type of physics," says David Sinclair, a senior scientist at SNO. Now in its calibration phase, SNO is expected to begin returning usable data later this year.

Meanwhile, the case for neutrino flavor mixing has received a tremendous boost from Super-Kamiokande, the world's other large solar neutrino detector. Super-K consists of a 12.5-million-gallon tank of ultrapure water standing 10 stories high inside a Japanese zinc mine buried under the Japanese Alps. It can only detect electron neutrinos from the sun, but because of its size it also records a significant number of muon neutrinos from Earth's atmosphere. These so-called atmospheric neutrinos are byproducts of cosmic rays colliding with air molecules. They can be detected coming both from above and below the detector, depending on which side of the globe they originated.

In June 1998, an international team of physicists at Super-K reported that only half as many atmospheric neutrinos have been detected coming from below the tank as from above. Because those neutrinos coming from below must first pass through Earth's full diameter before reaching Super-K, the extra travel time may allow some muon neutrinos to change into tau neutrinos along the way, powerful evidence that neutrinos have mass. "One by one we've eliminated all the alternative explanations," says Boston University physicist Alec Habig, a member of the Super-K team.

Scientists in the neutrino community were elated by the Super-K announcement, and many expect that SNO will complete the link between flavor mixing and the solar neutrino problem. But the final chapter may be written by another detector, called BOREXINO (for "Boron Experiment"), currently under development in Italy. When completed in late 2000, BOREXINO will be able to distinguish between electron and muon neutrinos from the sun with energies that are too low for either SNO or Super-K to detect. Since most of the sun's neutrinos are produced at these lower energies, BOREXINO will be needed to confirm whether the MSW effect is responsible for the entire solar neutrino deficit.

beyond the sun

Although designed primarily to capture solar neutrinos, the new generation of detectors also creates opportunities for neutrino astronomy well beyond the sun. High on the list of potential targets are nearby supernovae.

Supernova 1987A in the Large Magellanic Cloud, a satellite galaxy of the Milky Way about 170,000 light-years away, produced enough neutrinos to trigger a handful of detections on Earth. Ever since, astronomers have been tantalized by the prospect of collecting supernova neutrinos. "They bear the stamp of exactly what's going on in a region otherwise completely shrouded in mystery," says University of Arizona astrophysicist Adam Burrows.

Astronomers expect a supernova to form neutrinos in two ways. First, when a massive star's core begins to collapse to form a neutron star, electron neutrinos are produced when electrons and protons are squeezed together to form neutrons. For an instant, the density at the center of the collapsing stellar core is so high that not even neutrinos can escape. When they do, the neutrinos form an initial burst that signals exactly when and how the neutron star formed. Immediately afterward, neutrino-antineutrino pairs of all three flavors will form spontaneously and quickly escape the developing supernova. Neutrino detectors on Earth should see a combined neutrino signature from these two processes, consisting of a sharp spike of electron neutrinos followed by neutrinos and antineutrinos of all varieties. If the neutrino signal turns off abruptly, it would mean that the neutron star had continued to collapse into a black hole, an Alcatraz from which not even neutrinos can escape.

If a relatively nearby star goes supernova, neutrinos could provide astronomers with an unprecedented head start. When the core of a massive star collapses, it takes hours for a shock wave to work its way out to the surface and blow the star apart. But neutrinos escape in a matter of seconds. This ensures that neutrino detections will always precede the appearance of a nearby supernova. With the directional capability of detectors such as Super-K and SNO, astronomers may even know approximately which part of the sky to watch as they wait for the supernova to show up.

Supernovae in our galaxy are rare, occurring perhaps once every 30 to 50 years. But more reliable sources of neutrinos are thought to exist beyond the Milky Way. Gamma-ray bursts, for example, should produce neutrinos in addition to the powerful gamma rays and x rays now being detected by orbiting satellites. Other potential sources include the cores of active galaxies, where giant black holes are both swallowing matter and driving fast-moving jets of particles into intergalactic space.

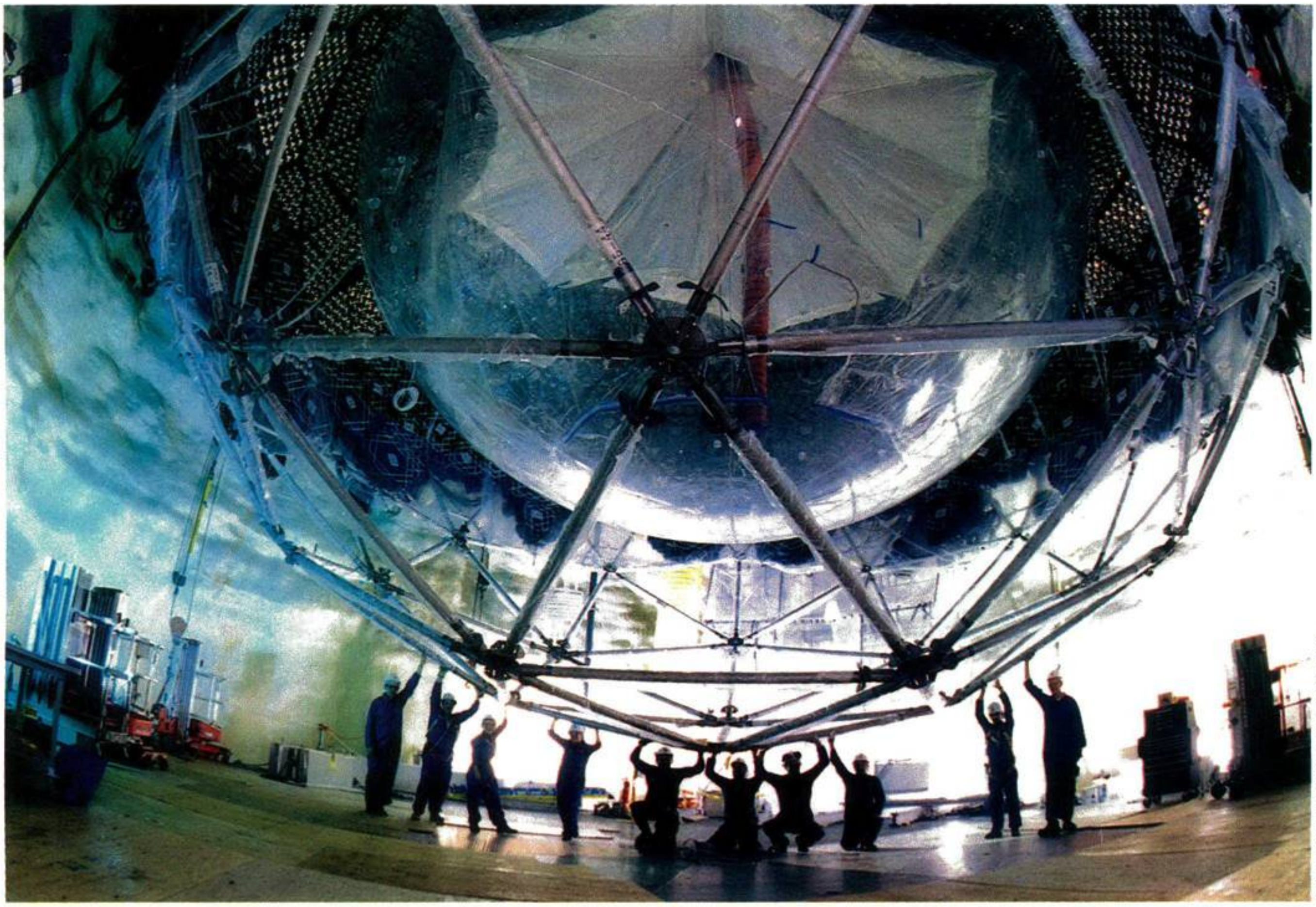
Anglo-Australian Telescope Board/Photography by David Malin

Neutrino detectors recorded about 20 neutrinos from Supernova 1987A. Modern experiments will give astronomers advanced notice of any nearby supernovae.

Because of their great distances, the numbers of high-energy neutrinos expected to reach us from these sources are very low. To compensate, detectors of extragalactic neutrinos must be enormous in size. The Antarctic Muon and Neutrino Detector Array (AMANDA), which operates at the South Pole, consists of long strings of light-sensitive detectors (called photomultipliers) sunk 1.5 miles (2.4 km) into the Antarctic ice sheet. At depths greater than a mile, pressure squeezes air bubbles out of the ice, rendering it clear. There, light detectors can spot the faint flashes generated by high-energy muon neutrinos interacting with neutrons and protons in the ice. As researchers continue to add more strings, the total volume of ice monitored by AMANDA will grow, eventually reaching one-quarter of a cubic mile.

cosmic connections

When the Super-K team announced evidence for neutrino flavor mixing last year, cosmologists were among those who pricked up their ears. Flavor mixing implies that neutrinos have mass — perhaps enough to account for some of the unknown dark matter that comprises more than 90 percent of the mass in the universe. With neutrinos outnumbering protons 600 million to one, "Even if neutrinos are not



Sudbury Neutrino Observatory/Bob Chambers

The Sudbury Neutrino Observatory in Ontario, Canada, will detect neutrinos as they pass through this 40-foot-wide acrylic sphere containing 240,000 gallons of heavy water. Results from this experiment could help resolve the nagging mystery of the missing solar neutrinos.

the total answer to dark matter, they could still be a crucial missing part," says Rocky Kolb.

Being so lightweight, neutrinos travel at near light speed. Neutrinos thus fall into the category of "hot dark matter" — matter that in the early days of the expanding universe streamed outward too quickly to contribute to the formation of galaxies. Instead, heavier and thus slower-moving particles of "cold dark matter" (the so-called "weakly-interacting massive particles," or WIMPs) are thought to have triggered galaxy formation by clumping together under the influence of gravity. Currently, the most favored cosmological models rely on a combination of cold and hot dark matter. A correct determination of the masses of the three neutrino flavors could provide an important limit on how quickly the universe came to its present state.

Unfortunately for cosmologists, neutrino detectors can only provide the mass difference *between* neutrino flavors, so more than one interpretation of the Super-K data is possible. If the tau neutrino is much heavier than the muon neutrino, then Super-K suggests the neutrinos are probably too lightweight to play much of a role in the formation of the galaxies. On the other hand, both neutrinos could be much heavier with only a slight mass difference between them.

The distinction between the two scenarios is critical, because the universe is believed to be full of neutrinos released approximately one second after the Big Bang. Calculations show that every cubic inch of space now contains about 1,600 primordial neutrinos, which should come in an equal mix of all three flavors. By combining the results of a variety of neutrino experiments over the coming years, scientists are planning to gradually narrow the uncertainties in neutrino mass.

Meanwhile, primordial neutrinos are a tantalizing quarry for astronomers because they can reveal what conditions were like in the universe a mere heartbeat after the Big Bang. However, the low energies expected from primordial neutrinos puts them beyond the range of any existing or planned neutrino detector. "It's a challenge for the next century," says Kolb.

The statement underscores the important role neutrinos are just beginning to play in our exploration of the universe. In this century, fundamental breakthroughs followed from the development of telescopes capable of seeing the sky at wavelengths beyond visible light. For many researchers, the current renaissance of neutrino detectors heralds a similar transition into a new era of "multi-messenger" astronomy. Someday soon photons, neutrinos, cosmic rays, and gravitational waves will combine to provide a richer view of the heavens than we can currently imagine. ■

Ivan Semeniuk is a science writer and broadcaster based in Toronto. He develops exhibits and programs at the Ontario Science Centre and reports regularly on astronomy and space science for the Discovery Channel, Canada.

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Cosmic FLOOD

Photons that arrive night after night as relentlessly as a swollen Mississippi are overwhelming astronomers with a deluge of data.

by Sharon Begley

It's not that Susan McMahon wishes bad luck on any of her colleagues at the Jet Propulsion Laboratory. Nor is it that McMahon, manager of the planetary-data service at JPL, wasn't as eager as everyone else for the Galileo probe and orbiter to uncover Jupiter's secrets. But when a slew of radio commands failed to deploy Galileo's high-gain antenna in April 1991, McMahon couldn't stifle a little "Thank God!"

With data now arriving only via the low-gain antenna — at a significantly lower rate than it would have over the high-gain — McMahon's Planetary Data System can just about keep up with the incoming bytes. "If we'd had to deal with the data return from the high-gain antenna," says McMahon, "we couldn't have. As it is, we're hanging on by our fingernails. Once Cassini (the mission to Saturn) and Mars Global Surveyor start returning data, I don't even want to think about what's going to happen."

She'd better think about it anyway. Astronomers are being buried in a deluge of data, a flood of photons that arrives night after night as relentlessly as the Mississippi overflowing its banks. Researchers are almost (or already, depending whom you ask) overwhelmed by it, missing nuggets of gold that wash past in a sea of junk or get buried forever in the muck. Space missions are declared over, their budgets for data analysis zeroed out, long before all the nuggets are panned; data collected years ago sit in storage media — anybody out there remember seven-track magnetic tape? — for which the players are about as rare as slide rules. It will only get worse. The all-sky surveys underway or on the drawing boards — with names like 2MASS, MAP, ROSAT, GALEX and SDSS — will produce terabytes upon terabytes of data.

The Sloan Digital Sky Survey, for instance, which is using a new telescope at Apache Point, New Mexico, to map half the northern sky in five wavelengths from UV to the near infrared, will detect more than 200 million objects. It will create an archive of 40 terabytes, says astrophysicist and SDSS investigator Alexander Szalay of Johns Hopkins University. "Even before these big surveys, we have been just barely keeping our heads above water," says astrophysicist Robert Nichol of Carnegie Mellon University. "With the Sloan survey, the faucet is being opened and the deluge is starting."

If this were a movie, a spectral visitor would give us an admonitory preview of what could happen if astronomy doesn't get its data house in order. Consider the cautionary tale offered by the National Space Science Data Center, at NASA's Goddard Space Flight Center. Formed in the mid-1960s, NSSDC stores data from as far back as the 1960s Explorer missions, which collected space physics data on, for instance, the Van Allen radiation belts that girdle Earth. The data from about 1,000 experiments that flew on some 400 missions comes to 10 terabytes, says director Joseph King. The problem is how those 10 terabytes are stored. King rules a realm of 4- and 8-millimeter tapes; a few years ago he had 7-track tapes. Soon, no one will even know how to read them. "Are the bit representations in ASCII or IBM binary?" asks King. "We've got data from computers that are no longer around, and if you want to read those data someone would have to show you, bit by bit, what binary representation was being used." Soon there won't even be machines capable of playing the old archives — which is why King's staff is transferring everything they can to CD-ROMs and optical disks.

James Yang

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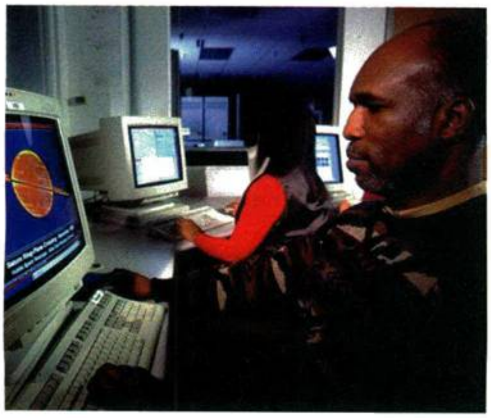
Why care about old data? "These archives include huge unmined data sets," says King. When someone realizes that and tries to dig one up, though, it can be like trying to read hieroglyphics without the Rosetta stone. Data from the Apollo missions were stored on 12-inch magnetic tape reels, for instance. "The tapes wound up in some storage space the university got hold of in a high school basement," recalls astronomer Floyd Herbert of the University of Arizona. "We were interested in some of the magnetic field data, but no one had a functioning (compatible) tape drive. We wound up copying the data onto 8 mm videotape, with software that lets you translate from one data storage medium to another. However, if we had waited a few more years we wouldn't have been able to do even that."

And that would be a colossal waste. "All of us in this business of data analysis say NASA doesn't fund enough of it," says Herbert. "If they did, they'd get a lot more out of what was so expensive to collect in the first place." That's become a common refrain. "There is some tendency, with NASA's 'faster, better, cheaper' mantra, that the data analysis teams are getting less support," says planetary astronomer William Hartmann of the Planetary Sciences Institute in Tucson. "So we have these massive databases but no one around to look at them."

Once a mission is officially over, it is nearly impossible to get NASA funding to comb through the data. The assumption is that the cream has been skimmed. But Hartmann argues that old data can be good data. "Even with the Viking images there is interesting science to be done," he says. "But there is no money to do it." Hartmann himself would like to comb through all the Mars images in the archives and calculate crater densities: the more impact craters, the older the landform. Without financial support, he prays for student volunteers.

Even more basic than analyzing data sets is storing them, and astronomers may be in trouble here, too. Take Brian Skiff's asteroid search at Lowell Observatory in Flagstaff, Arizona. Using a wide-field telescope with a digital detector, he scans the skies for near-Earth asteroids, especially those that might get too close for comfort. "We generate 8 gigabytes of data a night," he says. "With data coming in at such a prodigious rate, we don't have a place to store it." But they can't send it to the tempting little trash icon. In Skiff's line of work, old data are crucial to calculating trajectories. "If one night we see something interesting," says Skiff, "we want to be able to go back (to the object's earlier appearance) and calculate its path. So we're trying to keep as much as we can, copying it onto tape that holds 50 to 100 gigabytes." The key here is data compression. Skiff uses software that inventories each image and identifies those containing anything other than blank sky; it marks those with the computer equivalent of "there is information in this pixel," and compresses all the rest into something called "empty." That process squeezes the data by a factor of two or three.

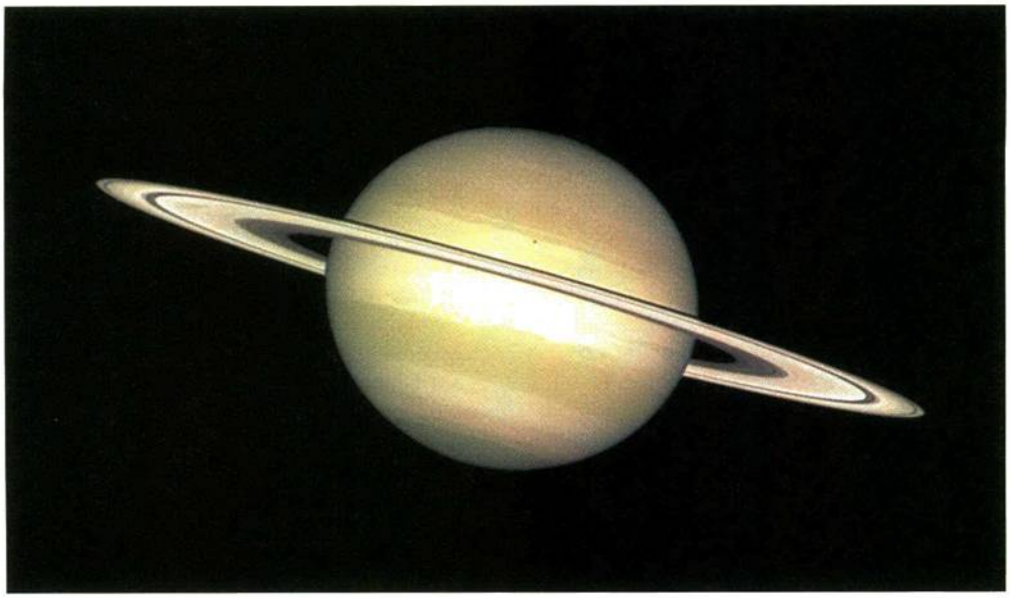


Herb Kennedy, data archive supervisor at Space Telescope Science Institute in Baltimore, Maryland, manages the glut of information created by the Hubble Space Telescope. John Dean and STScI

Astronomers are not, of course, the only ones caught in a data deluge. The nation's supersecret spymasters who work for the National Security Agency (NSA) receive so much raw data every day — from intercepted cell-phone calls, communications satellite transmissions, faxes, and e-mail — that it can reportedly analyze only 1 percent of what comes in, according to James Banford, author of a book on the NSA. In high-energy physics, researchers at Fermilab in Chicago routinely look for needles in haystacks: To discover the top quark, in 1995, they combed through more than 50 million collisions between subatomic particles to find a mere three dozen top candidates. The data came to 30 terabytes.

Starting in 2000, Fermilab and the European Laboratory for Particle Physics (CERN) in Geneva, Switzerland, are facing the prospect of experiments that will generate petabytes of data per year. So what's the problem? "Brute force does not work," says Hopkins' Szalay. "You can't simply scale up today's approaches to analyze data of this magnitude."

Think of it this way: Let's say Professor Nova is interested in a 500 gigabyte data set. Her university can receive data over the World Wide Web at the standard 15 kilobytes per second; at this rate she would have to wait a year for it. Her colleague, Prof.



The data archive of the Space Telescope Science Institute has about 16.6 gigabytes of storage space dedicated to images and spectra of Saturn. STScI

Cobe, is lucky enough to sit in the same building where the data are stored; using Ethernet, it takes him ... a mere week to download. Even the principal investigator who is logged on to the very machine on whose hard drive all of the 500 gigabytes reside would need a full day to scan through it all. "Even faster hardware cannot support hundreds of such brute force queries a day," says Szalay.

To wrestle the data from the new sky surveys into submission, therefore, will take nothing less than "a paradigm shift," says Szalay. "We need new tools to properly digest, warehouse, query, and analyze our data. The key to the scientific enterprise of the future will be the ability to manage, index, access, interpret, and analyze these enormous data sets."

How much are we talking about? Take OGLE, the Optical Gravitational Lensing Experiment. Begun in 1992 at the Las Campanas Observatory in Chile, and since 1996 using the dedicated Warsaw Telescope there, OGLE searches for the galaxy's dark matter by looking for microlensing events. Gravitational lensing results from the ability of massive objects to bend light, kind of like a bowling ball positioned in the center of a trampoline deflects — downward — the path of a line of ants marching from one side to the other. Gravitational lensing bends light from a background galaxy into multiple paths, so the light reaching us is 10 or 100 times brighter. OGLE looks for such signatures. Taking data every night, says Bohdan Paczynski, the Princeton University astronomer who first proposed using lensing to spot dark matter, OGLE is collecting some 300 gigabytes per year. With a new detector coming on line late this year or early 2000, the rate will increase 16-fold, and OGLE will be swamped by 4 to 5 terabytes per year.

OGLE's collaborators aren't worried about storage — they've gone to digital linear tape, which stores 20 gigabytes per cartridge. The problem is access. "We try to put our data — processed and with the errors cleaned out — in the public domain almost immediately," says Paczynski. "In the best case, that's about a year after we take it." The only practical way to share the data is over the Internet, but remember Szalay's calculation: 500 gigabytes would take a year to stream over a standard connection.

MACHO has already discovered this. This collaboration searches for Massive Compact Halo Objects, also by gravitational lensing. Its primary aim, says astronomer Charles Alcock of Lawrence Livermore National Laboratory, is to test the hypothesis that much of the dark matter in the Milky Way's halo is made up of MACHOs, non-luminous objects such as brown dwarfs or planets whose signature would be the amplification through lensing of light from extragalactic stars. Because such events are so rare, the team monitors millions of stars for years to get a statistically meaningful detection rate.

GLOSSARY OF GIGANTIC NUMBERS

mega-: million; 10^6

giga-: billion; 10^9

tera-: trillion; 10^{12}

peta-: quadrillion; 10^{15}

"All of us in this business of data analysis say NASA doesn't fund enough of it," says astronomer Floyd Herbert. "If they did, they'd get a lot more out of what was so expensive to collect in the first place."

All astronomical data will eventually be interconnected through high-speed networks to allow astronomers to make discoveries without ever again being frustrated by bad weather.

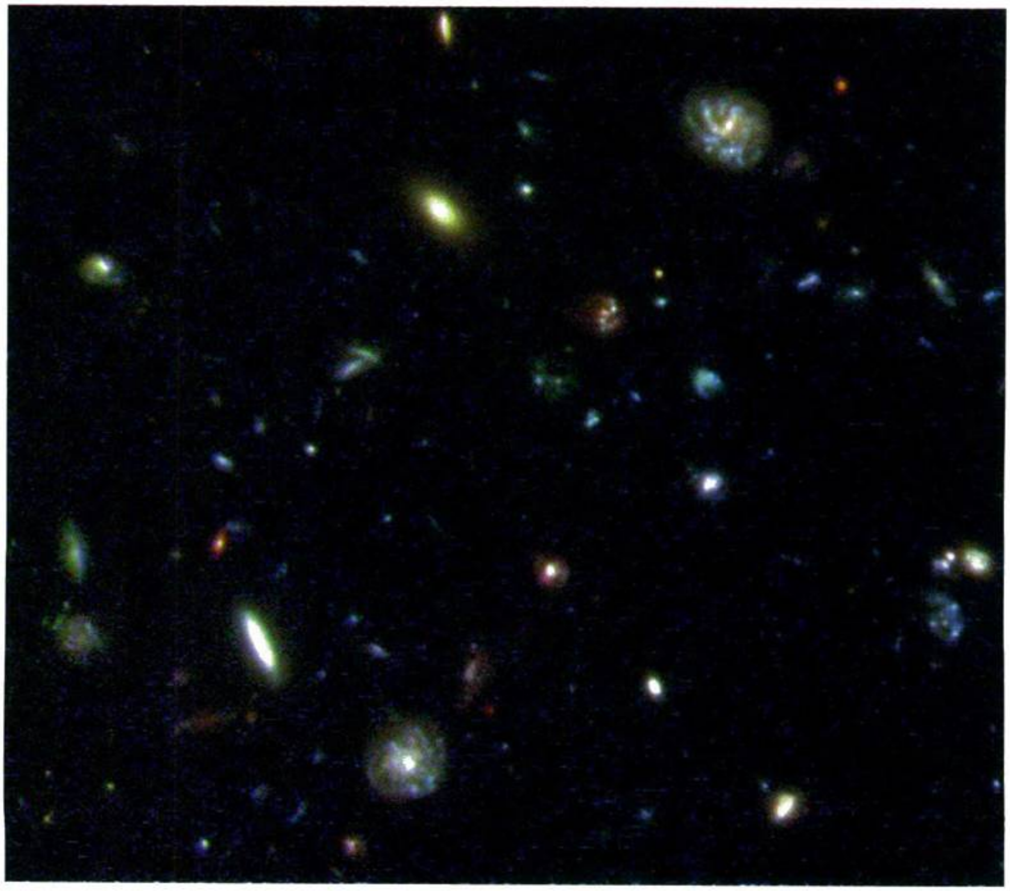
Using the 50-inch telescope at Mt. Stromlo and Siding Spring Observatories in Australia, MACHO takes images of the Large and Small Magellanic Clouds, gathering gigabytes of data per night. Since the project started in July 1992, it has amassed 6 terabytes of data on 66 million stars and will add 1 terabyte per year, says Alcock.

Whose data is it, anyway? Astronomical tradition is to let the principal investigators milk it for all the papers they can. "In the beginning all of us felt very powerfully that we should have the rights to these data, but it quickly became clear that it was too much," says Alcock. "Once that set in, people quickly became more generous — or at least they didn't complain too loudly." The problem is, with gigabytes or terabytes, you can't just say, Here it is. Astronomers want processed data — reduced, calibrated, usable. A plan to share the MACHO data within two years foundered on the lack of funds to set up a web server through which astronomers could access it. "No one knew what it meant to have this much data," Alcock says. "The process of making it all available to the community would require more people and resources than we have. We can't do it on a web server. We're hoping to get it out on CD-ROMs." The irony is that few astronomers will use it. They won't have the computational capacity to reduce it. Says Alcock, "Our ability to gather data is increasing rapidly, but our ability to make sense of it isn't keeping up."

The Sloan Digital Sky Survey will contain at least 10 times more data, by the end of its planned five-year run, than any other sky catalog: 40 trillion bytes, enough to fill 20 million floppy disks. No, they're not going to actually fill and stack those disks. But even with the data stored on CDs or more advanced media, retrieval could be a nightmare: Standard cross-referencing could take longer than waiting for tenure, and astronomers could not compare Sloan data to those in other star catalogs. That would not be good. The Sloan archive will become "the standard reference to study the evolution of the universe," says Szalay. Unless someone figures out how to cross-reference and index the data — to make it "queryable" — the archive will be approximately as useful as the pages of a 20-volume encyclopedia that have been torn out of their bindings and cut into one-inch squares.

Luckily, one scientist's problem is another's opportunity. Just when the data deluge threatens to drown astronomy, in

The Hubble Space Telescope's Deep Field South observation accumulated 44.8 gigabytes of data.
STScI



rides — trumpet fanfare, please — the equivalent of the National Guard to pluck survivors off their roofs and whisk them to safety. Szalay and others think they have solved the problem, by designing an archival system based on parallel programming that will let astronomers using the Sloan data analyze several terabytes per hour. Without getting into the cyber-arcana, Szalay and colleagues are developing a sophisticated search engine to bridge the chasm between the data they can store and the data they can mine. Data will be coded and stored in cyber-containers: Each storage space will hold similar objects — blue galaxies, say — from the same region of the sky. This storage scheme will allow an astronomer to submit a query such as this: Find all the objects similar to one set of objects (say, type I supernovae) and dissimilar from another set (not in the Southern Hemisphere, for instance). Or this: How many clusters of galaxies have an ancient central galaxy? This is an example of a correlation — a cluster linked to an ancient galaxy — and it may prove to be a common kind of query posed to the Sloan database. "In the past," says CMU's Nichol, "we needed correlations in just position, color, and brightness. Today, the correlations we can look for and the amount of information we have to draw from has expanded dramatically." How dramatically? "There are trillions of high-order correlations, each requiring billions of computations," says Andrew Moore, an assistant professor of computer science and robotics at Carnegie Mellon University.

Yet he's undaunted. In November 1998 Carnegie Mellon received $1.6 million from the National Science Foundation (NSF) to create smart and nimble computer programs to "patrol astrophysical data and make discoveries about how the universe evolved into its current structure," says Moore. "Basically, we're proposing to help automate the process of scientific discovery where there is too much information for a human being to even have the chance to spot patterns, regularities, and anomalies." His money is on an algorithm he developed in 1997, dubbed "all-dimensions trees." The algorithm scans data, discover correlations, or make counts, 50 to 1,000 times faster than standard brute-force methods. The new software, says Nichol, also a member of the Sloan Survey team, will mean "a new epoch of data analysis."

Observation specialist Mark Kochte, left, astronomer Helen Hart, center, and archive analyst Tim Kimball, right, discuss STScI's data archive. John Dean and STScI

Call it the dawning of the age of the "National Virtual Observatory." In Szalay's vision, all astronomical data will eventually be archived, indexed, cross-referenced, and interconnected through high-speed networks and patrolled in such a way as to allow astronomers to make discoveries without ever again freezing their behinds at a telescope on long cold nights or getting wiped out by bad weather.

"Astronomers will have to be just as familiar with mining data as with observing on telescopes," says Szalay. He even suggests a heresy: that there would be a higher return from assembling the requisite archive than from building the next great telescope. "This is a new paradigm, a new way of doing science," says Hopkins' James Crocker, director of program management for the Sloan survey. "To answer questions you will go into the data base and 'data mine.' So you are looking at this data set rather than the sky." But the time to consider it is now, not in five years. By then, many of the tera-surveys will have completed their archives; they will exist on different computing platforms. Trying to integrate them all would require rebuilding each from scratch.

A virtual observatory presents at least one epistemological problem, though. Data bases such as MACHO, OGLE, and Sloan are so big "they can be looked at only with computer programs," points out MACHO's Alcock. "We can program our computers to search through the haystack and find a needle, but only if we know what the needle looks like.

But the big discoveries in astronomy since World War II — such as pulsars, quasars, and the cosmic microwave background — were completely unexpected. Almost by definition, we don't have algorithms to look for the unexpected — we can only tell the computer what it should look for, so in a sense we are blind to discoveries that we can't foresee." That, however, may simply be the price astronomers have to pay for deliverance from the cosmic flood. ▣

Sharon Begley is science editor of Newsweek.

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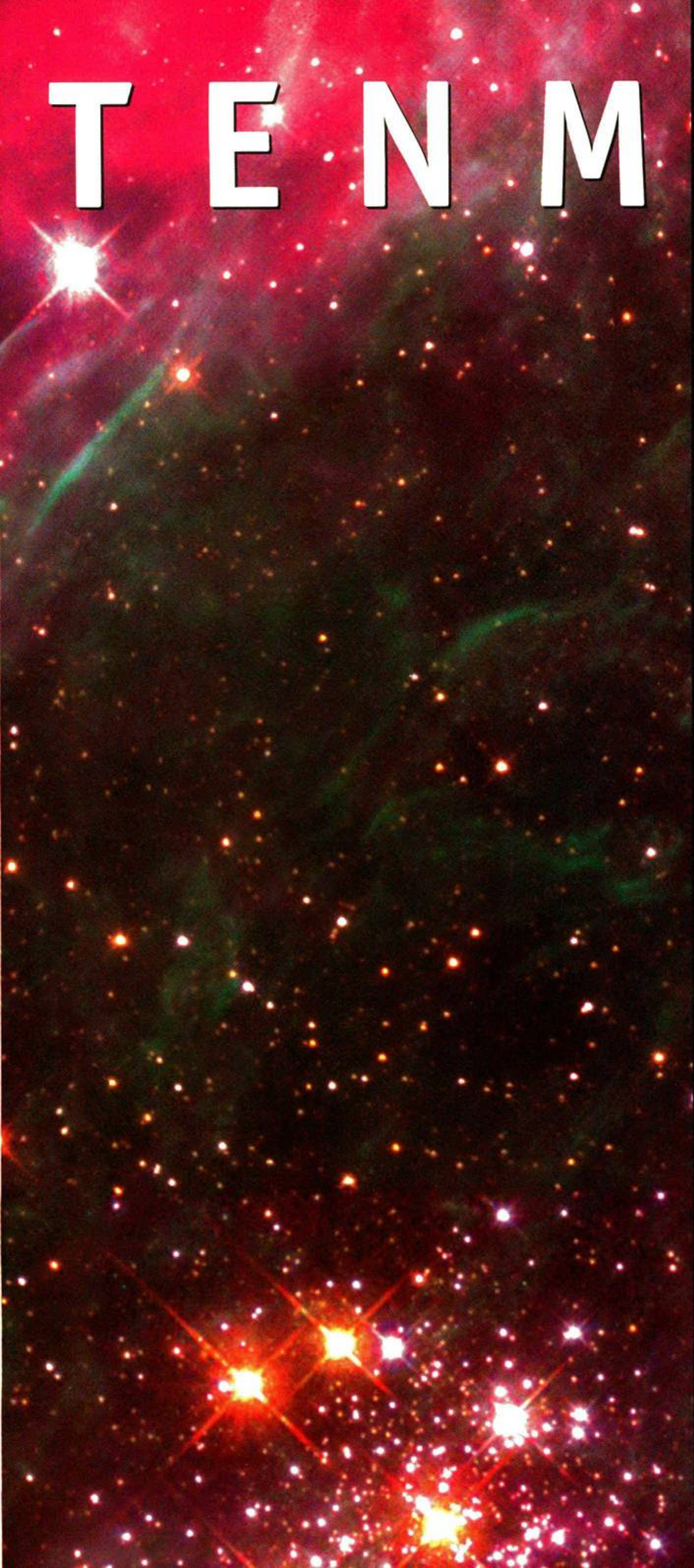

Space Day aims to make the future of science brighter.

by Andrea Gianopoulos

Stand close to one of Claude Monet's Giverny garden paintings and the swaths of color seem to form a random array of speckled blobs. With increasing distance, these pigments and their shading form patterns — lavender-hued irises, ruddy-brown tree trunks, emerald and lime-green leaves, each with its reflection in a shimmering turquoise pond. Similar to a great painting, astronomers use light and the different wavelengths at which it radiates to depict the universe. Their use of color helps convey the subtleties of an object's form. The pigments used may represent a temperature range, wavelength, or the intensity of a signal. Each color brings into view an otherwise invisible universe.

The process of scientific discovery through light and color is just one of three topics (the others being gravity and moon phasing) covered in *The Quest in the Question*, a free electronic field trip held in conjunction with Space Day, May 6, 1999. This annual event, now in its third year, explores the nature and history of science through electronic lessons, a live satellite broadcast, and a series of hands-on

The edge of the Tarantula Nebula is the focus of this latest Hubble Space Telescope Heritage image. The star cluster in the lower right (Hodge 301) is roughly 18 million years older than its 2 million year old neighbors at the nebula's center. Many of Hodge 301's stars have completed their evolutionary cycle as supernovae. Ejecta from these exploding stars is plowing its way through the nebula at more than 200 miles per second, shocking and compressing the gas into the filaments seen toward the upper left. AURA/STScI/NASA

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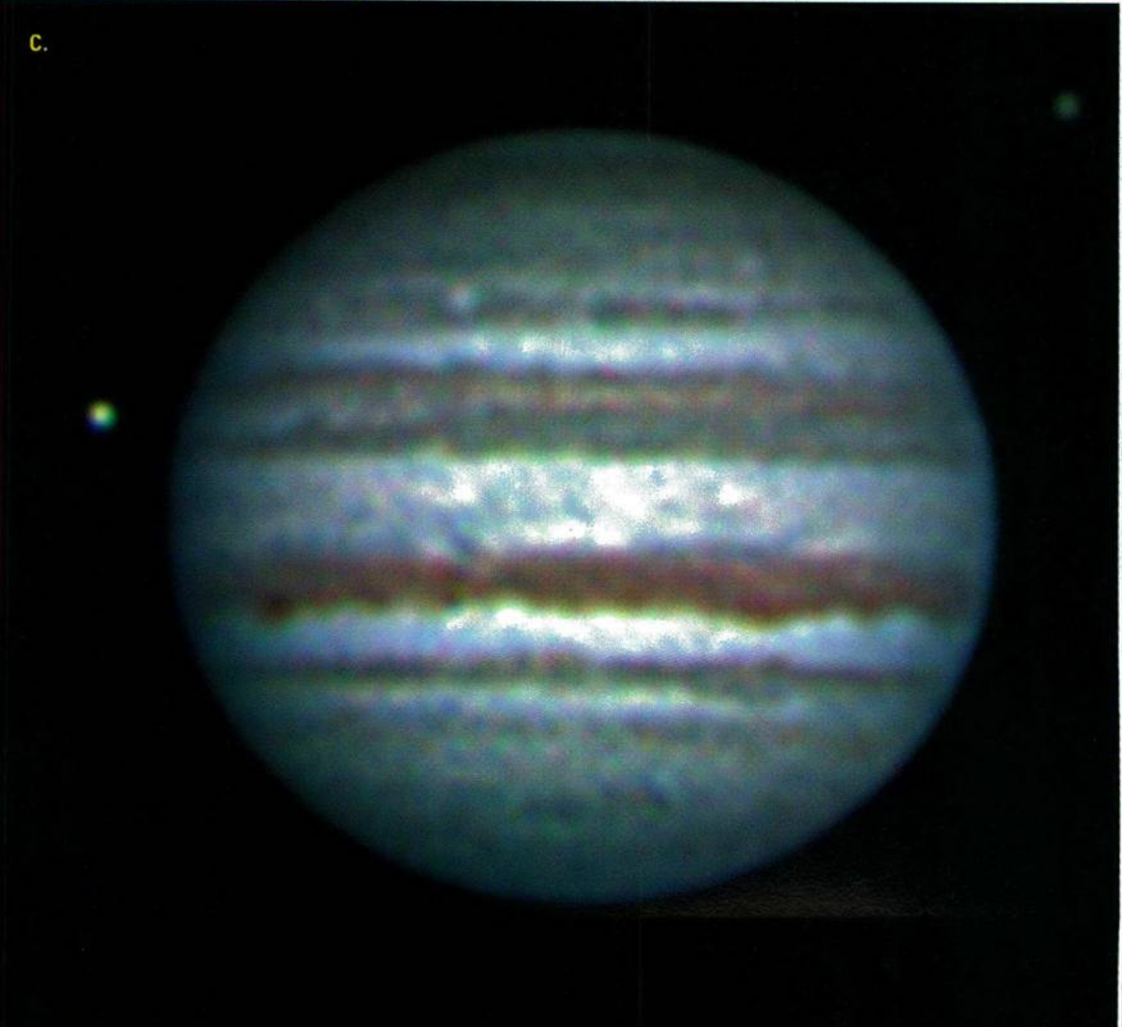
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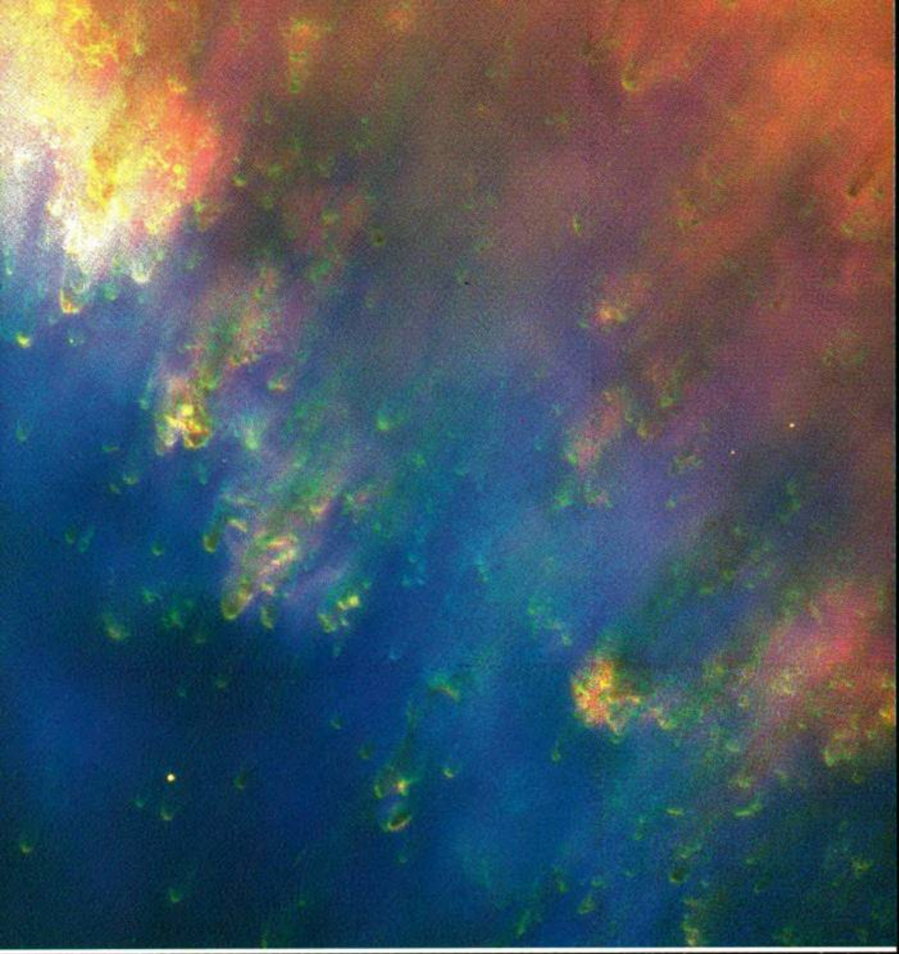

activities for children. "Participants not only learn the scientific method, but the creative and inquisitive process involved in scientific investigation," says Kelly Ray, Challenger Center Project Lead. "It strives to teach children that science is something everyone is capable of doing," she adds.

Founded on April 24, 1986, by the families of the Challenger 51-L crew, The Challenger Center for Space Science Education is an international organization dedicated to teaching science. They and NASA are the two primary educational partners for Lockheed Martin's Embrace Space initiative — from which Space Day had its beginnings.

Embrace Space started as a corporate education project at Lockheed Martin in 1996. Space Day developed as a vehicle to convey their educational mission. The event "uses the enthusiasm associated with space to focus young people toward an interest in math, science, and technology," says Hugh Burns, Space Day coordinator for Lockheed. The goal is to raise scientifically literate adults that will enter the workforce some 15 years in the future. "In our first year the electronic field trip reached 10 percent of the elementary schools in the country. Last year we reached 20 percent, or 4.5 million kids," remarks Burns. This year 4 to 6 million children are expected to participate.

Along with the satellite broadcast, the electronic field trip also includes an interactive webcast dedicated to space. Here

A. Look for the dark dust lanes of the Trifid Nebula to soften with a blue filter, while red highlights them. David Hanon **B.** The collision of two gases in the Helix Nebula creates tadpole-like features whose heads are twice the size of our solar system. How do the red and blue filters affect what we see in these gases? c. Robert O'Dell/Kerry P. Handron/NASA/STScI **C.** The color of Jupiter's clouds indicates where in the atmosphere they lie. The darker belts are deeper than the white zones. The blue filter better defines their boundaries, while red brings out features within the zones. David Hanon **D.** Look for knots and filaments in the dust lanes with the blue filter. The red filter reins in the Andromeda Galaxy's bright halo to better define its spiral structure. Tony Hallas

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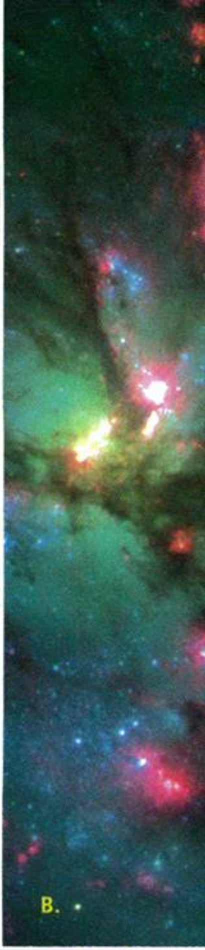
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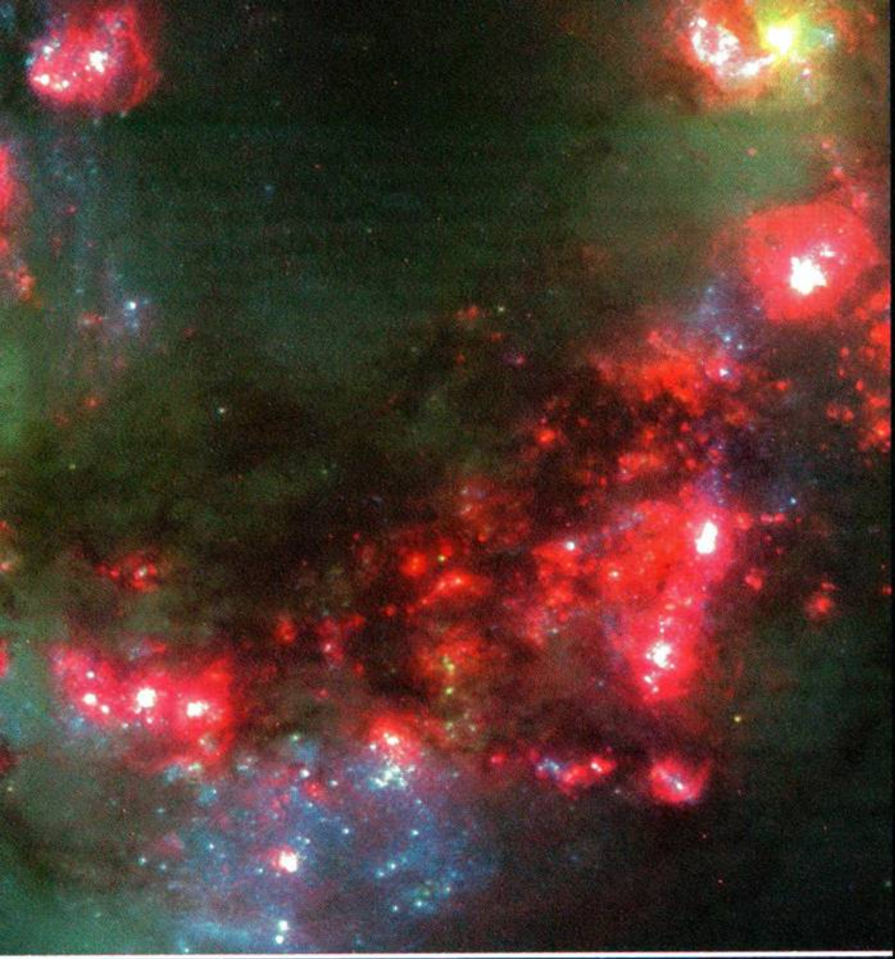


students of all ages will meet the people who plan the missions, do the research, and design the machines (http://www.spaceday.com).

The photographs on these pages will be used in classrooms across the country. Students begin the activity by analyzing visible light with prisms and filters. They predict what may be "hidden" in the light before making and recording their observations. Once they've "discovered" that white light holds a rainbow, they move on to use blue- and red-colored filters. The effect of each is predicted, observed, and recorded.

You and your child can participate as well. Start by making your own light filters. Do this by folding an index card in half, then cut a square out of the side opposite the fold — when the card is opened, it looks like an "H." Tape red cellophane over one of the square cutouts and blue cellophane over the other. Make the red cellophane darker by coloring it with a red Sharpie pen. Do the same to the blue side with a blue Sharpie pen. Those who still have their 3D glasses from the March 1998 issue can use them instead. Just be sure to use each color separately.

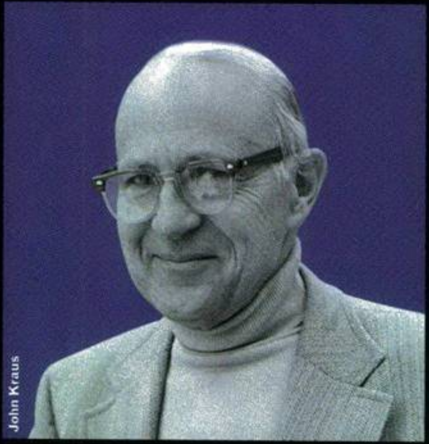
Start the experiment by predicting, then observing and recording your observations. What effect does each filter have? Does the image have something hidden in it? The images on these pages show dramatic differences between the red filter view and the blue filter view. Above all else, have fun as your child learns a bit about the science of astronomy.

A. The diffuse nebula around the star Sadr (Gamma [γ] Cygni) disappears in the blue filter. Steve Mandel **B. Two colliding galaxies, called the Antennae, trigger star birth. Look for hot, young, blue star clusters, red hydrogen gas clouds, and each spiral's bright core (center left and upper right).** Brad Whitmore/STScI **C. Yellow and red giant stars and smaller blue giant stars dot the globular cluster Omega Centauri. How do the views of the cluster through the filters affect these stars?** James Foster **D. How do the red and blue filters affect the bright blue Witchhead Nebula? Does this effect differ from the filtered views of the nebula around Sadr (image A)?** Tony Hallas

Meet the RadioMan

Maybe you can't make a silk purse out of a sow's ear, but John Kraus could make Big Ear out of an empty purse.

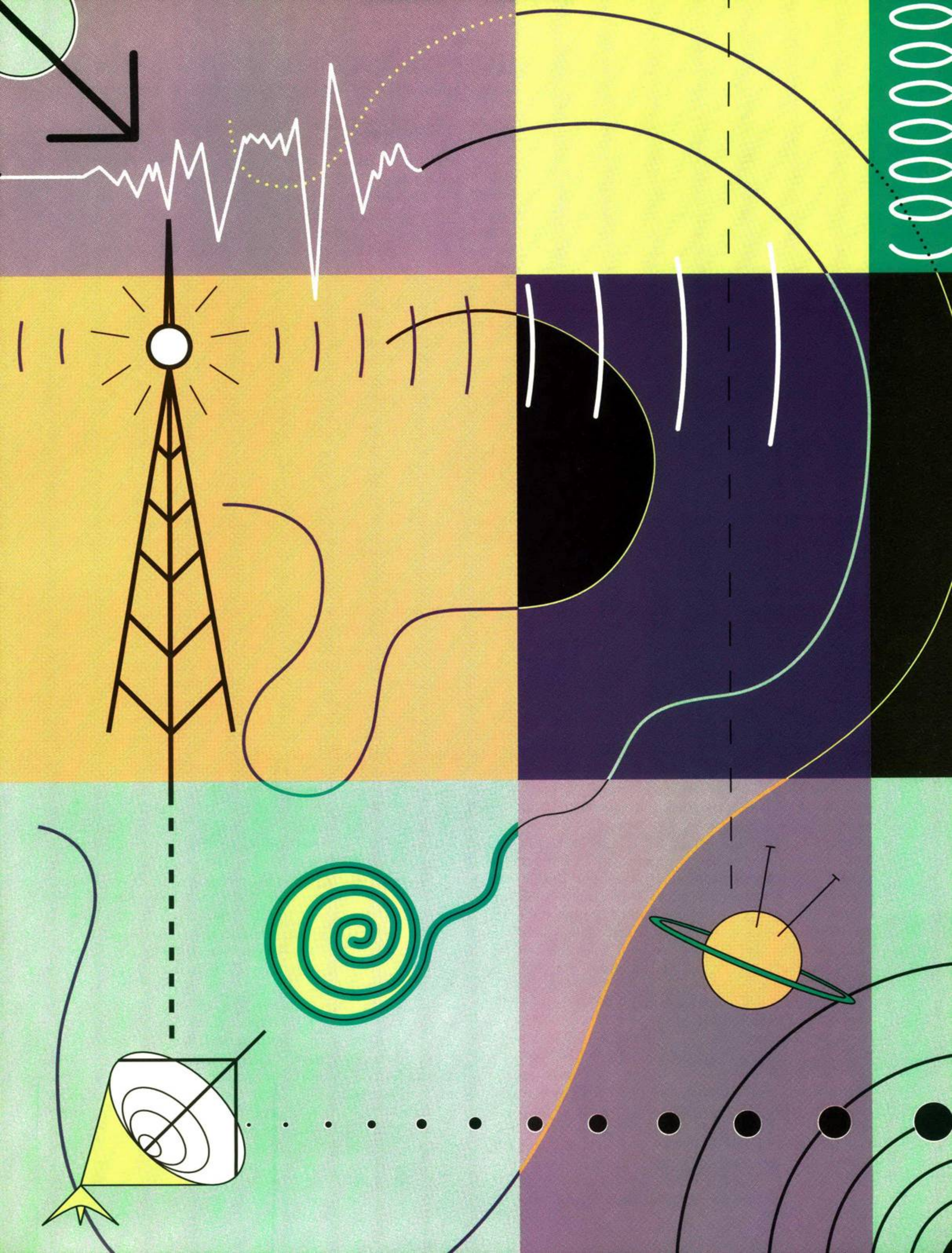
Text by Doug McInnis and illustration by Terri Field


John Kraus

In 1920, a 10-year-old boy in Ann Arbor, Michigan, took wire from the spark coil of a Model T Ford and wrapped it around an oatmeal box. He added an earpiece from his family's telephone, a tiny bit of hair-thin bronze wire, and some scraps of black galena crystal donated by his mineralogist father. He assembled the pieces into a crystal radio receiver and hooked it to an antenna of copper wire and glazed ceramic insulators. The crude radio pulled music from Detroit radio station WWJ — just 37 miles away. But to young John Kraus the effect was magical.

Four decades later, using technology akin to that tiny crystal radio, Kraus designed and built the famed Big Ear radio telescope just north of Columbus, Ohio, which would peer a record 12 billion light-years into space, probing quasars near the edge of the visible universe. In 1977, Big Ear recorded a powerful, narrow-band signal from deep space. When Jerry Ehman, the operator in charge of data analysis, looked at the signal, all he could do was write the word "Wow!" in the margin of the computer printout. Two decades later, the "Wow! signal" is still the strongest beacon that might be construed as a transmission from an extraterrestrial civilization.

John Kraus, the force behind these discoveries, is now 88. But he continues to labor long hours. He sandwiched the interview for



this story between work on the fifth edition of *Electromagnetics*, a widely used college textbook for physics and engineering majors, and the arrival of a delegation of German astronomers at his Delaware, Ohio, home.

BASEBALL CAN WAIT

Young John Kraus had a bent for science and invention. But his heart was on the baseball diamond, where he played first base and dreamed of the major leagues. Over time, though, he set his sights on the more realistic goal of scientific exploration. Kraus's father taught mineralogy at the University of Michigan, and the boy was constantly exposed to new ideas and his father's famous friends. Sunday dinner guests included Nobel laureates Enrico Fermi and Werner Heisenberg — on the same day. "Something must have rubbed off," says Kraus.

Kraus grew up in the tail end of the era of Midwestern tinkerer-inventors, a group that included Henry Ford, the Wright brothers, and Kraus's own idol, Thomas Edison. From his boyhood on, he took after them. The result was a hybrid. Kraus was the product of a classical scientific education and the tradition of trial-and-error invention. The combination produced amazing results.

While Kraus's interest in radio developed as a boy, his evolution into a world-class radio astronomer took decades. Kraus earned his doctorate in physics from the University of Michigan in 1933, the fourth year of the Great Depression. With few prospects, he felt lucky to find commercial research work at the university, where his first project required resolving the noise problem in refrigerators made by a Detroit manufacturer.

In 1934, Kraus traveled around Europe for six months. His first stop was Germany, which had just fallen under the dark cloud of Nazism. As soon as Kraus arrived, he encountered brown-shirted thugs and incessant cries of "Heil Hitler." Out of curiosity, Kraus attended a Nazi rally during which a throng of two million people fell sway to one of Hitler's infamous speeches. "The content of Hitler's talk and his method of delivery showed careful preparation by a master of mob psychology," wrote Kraus in his 1994 autobiography, *Big Ear Two: Listening for Other-Worlds*. "We had entered a mad, sick, tormented Germany where Adolf Hitler was God."

A few days later, Kraus left for the Soviet Union. Kraus didn't know it at the time, but Russia was in the throes of a famine, the result of Stalin's disastrous farm collectivization program. "Wherever we went in Russia, there were always crowds of ragged, gaunt people milling around the railroad stations or boat landings," recalls Kraus. "They carried cloth sacks over their shoulders or at their sides. Many seemed convinced that no place could possibly be worse than where they were."

After returning to America from his European tour, Kraus bounced around from project to project for a dozen years. He helped wire the cyclotron at the University of Michigan. He helped to modify paper-making machines. He worked on new designs for antennae. These and other tasks honed his inventive skills and his ability to see how seemingly unrelated ideas fit together. They also sharpened his knack for research on a shoestring budget. Long before Congressional budget cuts forced NASA to build "faster, better, cheaper," Kraus had mastered the art. After all, Kraus made his first radio from odds and ends — and it worked.

In 1939 he met a University of Michigan graduate student in bacteriology named Alice Nelson. The couple married just a few weeks after the United States entered World War II. (They recently celebrated their 57th anniversary.) During the war, Kraus worked on a project at the Naval Ordnance Laboratory in Washington, D.C., to protect Allied ships against magnetic mines.

For all his background, Kraus initially found no takers when he sought a university job that involved both teaching and research. Then, in 1946, an unsolicited offer came from Ohio State University's electrical engineering department. Kraus jumped on it.

SEARCHING FOR NEW IDEAS

Within months of his arrival, he came up with one of the inventions that would make his name. The moment came as he watched a visiting lecturer demonstrate a traveling wave tube, a device that amplified short wavelength signals by firing an electron beam down a long helix. When the lecture ended, Kraus asked, "Do you think a helix might work as an antenna?" "No," the visitor replied. "I've tried it and it doesn't work."

Kraus wasn't satisfied. Lacking a campus laboratory, he experimented in his basement workshop amidst laundry Alice had hung up to dry. In a moment reminiscent of the 10-year-old boy's first radio, Kraus fashioned a helix by wrapping a wire around a cardboard mailing tube and connected it to a war-surplus oscillator. The resulting contraption looked like a corkscrew sticking out of a tin can, but it led to a revolutionary antenna design that Apollo 14 astronaut Alan Shepard placed on the moon to relay information to Earth. Today, helical antennae are widely used on Global Positioning Satellites.

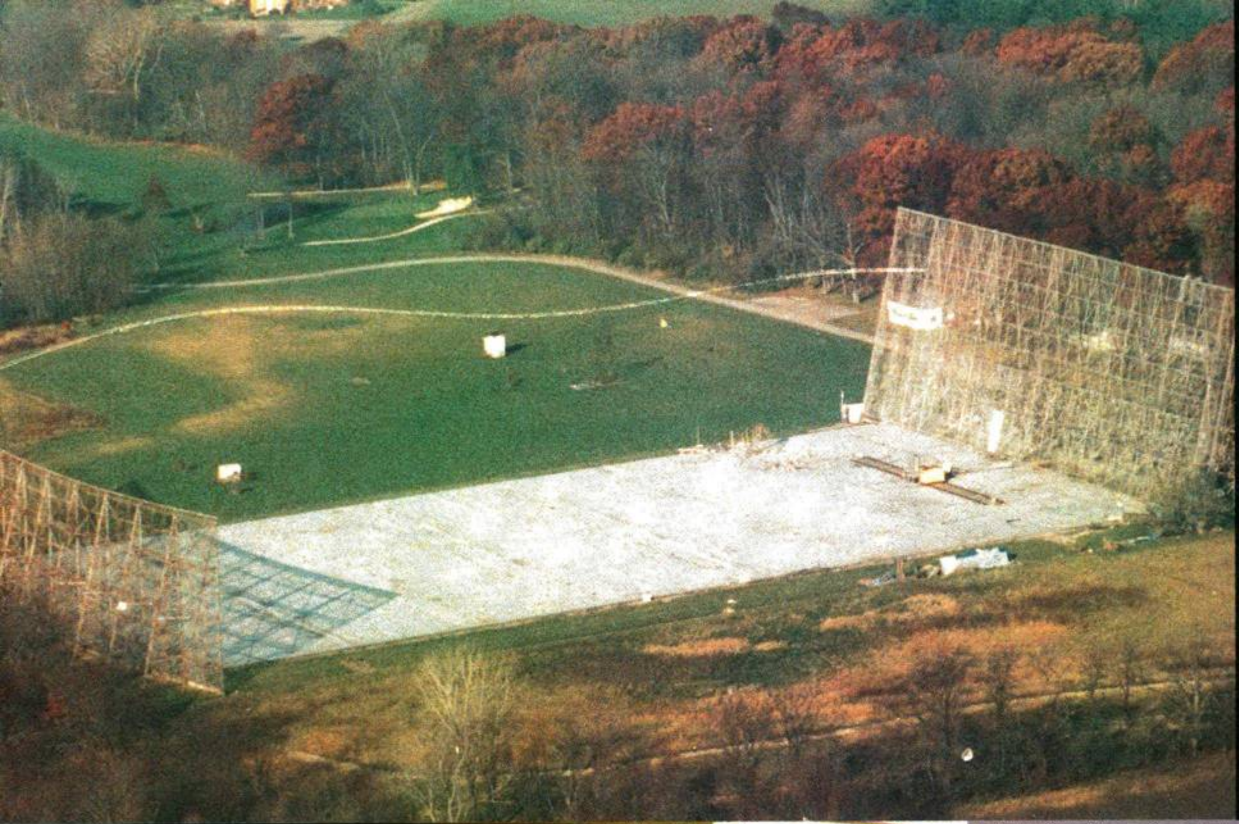
The invention illustrates the way Kraus solves problems. Kraus took a leap of imagination and turned the helical form into a potent new antenna. Kraus says such theoretical breakthroughs come from allowing the mind to roam. "You put your mind in a radar search mode. You start scanning ideas. And maybe a couple come together."

That type of thinking is aided by Kraus's love of taking gadgets apart and putting them back together. It is a type of thinking that relies on the mind. "We depend so much on computers to do our thinking," he says. "But they don't think. They just dish out what you put in. The human mind is the unique computer."

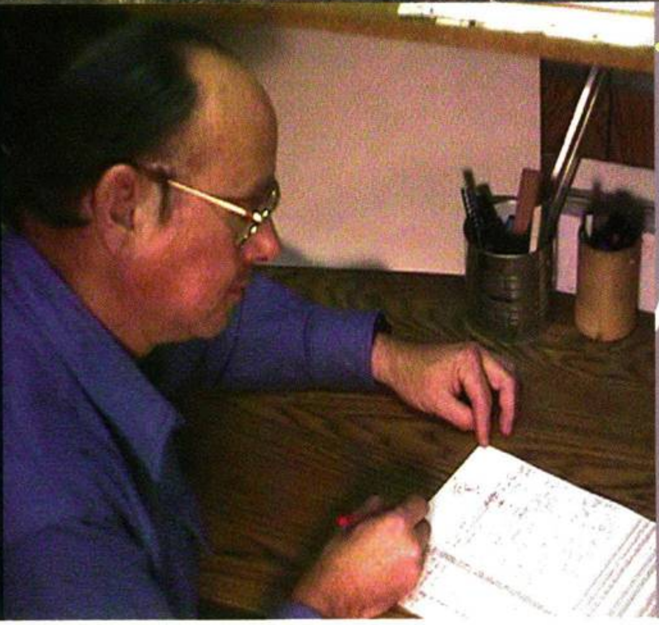
Kraus laments the loss of tinkering as an inventive art. "We take a lot of things for granted now. We embrace high technology, but we don't understand it. In the early days, if you had an automobile, you understood a lot about it. You had taken it apart several times. You had your hands on it. Now products have warranties which are void if you do anything with them."

The helical antenna experiment followed a pattern that was to mark Kraus's years at Ohio State. Chronically short of equipment, lab space, and money, Kraus got by with less when others might have quit. For example, Ohio State's first radio telescope sat on the university's farms next to an ever-expanding manure pile. But at least Ohio State had a radio telescope. At the time, Harvard and Cornell were the only other institutions to own one.

During this period, Ohio State lost a young zoology researcher because he was unable to get the university to build a shed for his work. When Kraus needed an equipment

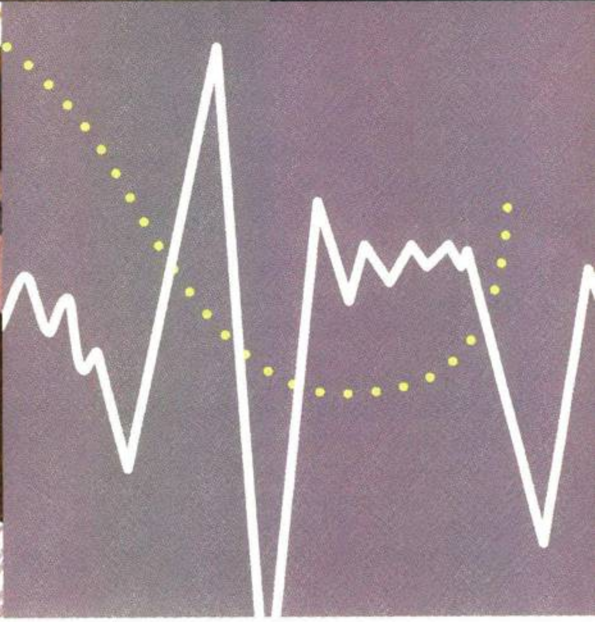


The Ohio State Big Ear radio telescope built by John Kraus and his students was larger than three football fields. Despite Big Ear's size, it used essentially the same technology as the radio Kraus built when he was a teenager.



Jerry Ehman examines the famous Wow! signal, which has the characteristics of an artificial beacon.

All photos this spread:John Kraus



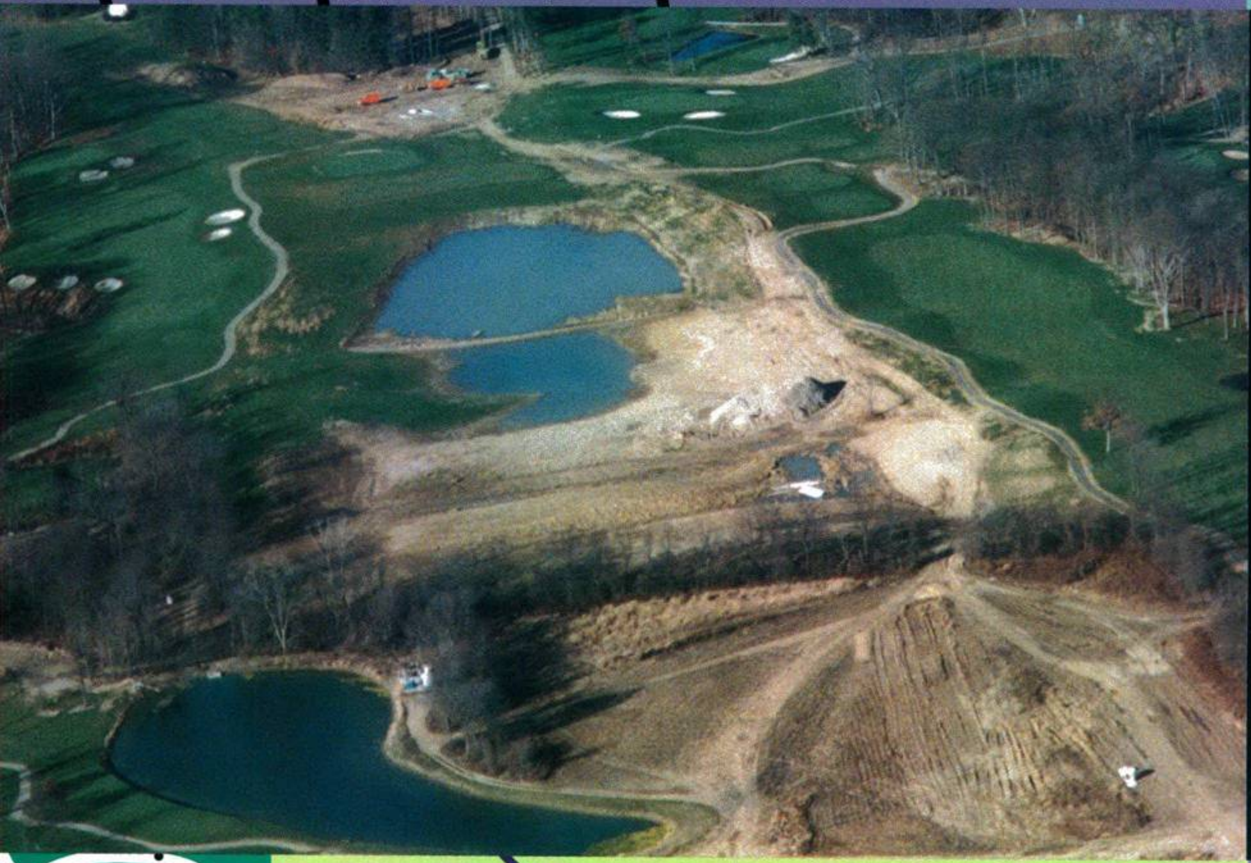
building next to the telescope, Ohio State never had a chance to say no because Kraus never asked. Instead, he requisitioned the needed materials and put up the structure himself with the help of a graduate student.

REACHING FOR THE HEAVENS

In 1956, Kraus began the undertaking of completing the second generation radio telescope that was to become Big Ear. There was only one problem — money. With only a $48,000 grant from the National Science Foundation, Ohio State couldn't afford a state-of-the-art radio telescope, so Kraus reverted to form and designed a potent new telescope that would save money while advancing technology. With the help of student labor, he went to work building this innovative new device on a 20-acre tract of land owned by nearby Ohio Wesleyan University.

Kraus shaved costs at every turn. He scrapped plans for a Frank Lloyd Wright-style administrative building that would have cost $100,000 in favor of a plain prefabricated metal building that cost $15,000. When one student mentioned he had been a welder, Kraus set him to work teaching other students. Soon Kraus had 10 student welders working for $1.50 an hour.

Traditional radio telescopes use a parabolic dish antenna that can be elevated and aimed in any direction. But the hardware required to make them work raises the cost. In addition, raising the height of an antenna has a geometric impact on costs; for example, doubling the height increases the cost eightfold. But doubling the width only doubles the cost. So Kraus designed an alternative, which looked like a giant football field with grandstands at both ends. A movable flat reflector at one end could be elevated up or down. But



The home of Big Ear, which peered 12 billion light-years into the past, has been transformed into a golf course.

Doug McInnis

there was no need to add equipment to point the reflector at specific points in the sky; Kraus let Earth's rotation take care of that. This reflector bounced radio waves into a huge fixed parabolic antenna at the other end. Big Ear's low profile made it much less susceptible to interference from Earth-based radio and television signals. The end product was a low-slung design that saved money and made scientific sense. Telescope builders in France and Russia copied the innovative scheme.

When Kraus and his band of student laborers completed their construction, they had delivered the world's most sensitive radio telescope at certain wavelengths for about $250,000. "Today, a university would never allow a professor to be the general contractor," says Kraus. "But if we had gone through a general contractor, the cost would have been 10 times as much."

Observations began in 1963, 43 years after Kraus built his first radio. But the technology is really the same. As Kraus notes in his autobiography, "A big radio telescope is simply a big antenna with a receiver attached."

With Big Ear, Kraus and his colleagues started mapping the heavens in the radio spectrum, picking out objects that would be almost impossible to find using optical telescopes. These maps showed the sky coordinates and the strength of the radio emission of each object. The work was tedious, time consuming, and exacting, but the results were occasionally spectacular. In 1970, Mirjana Gearhart, a young graduate student, found a distant body that would upend our concept of the universe. The object was a quasar that Kraus's team named OH471. In visible light, OH471 was barely noticeable, but as a radio emitter it leapt out.

Three years later, astronomers Robert Carswell and Peter Strittmatter at the Steward Observatory in Arizona obtained a visible light spectrum to establish that OH471 had an astounding redshift of 3.4. A distant object's light is redshifted because the universe is expanding, stretching its wavelength to longer and longer wavelengths, or toward the red end of the spectrum. With a redshift of 3.4, OH471 was receding at a billion kilometers an hour at a distance of 12 billion light-years. The news made the front page of the April 8, 1973, *New York Times*. *Time* magazine hailed OH471 as "the blaze marking the edge of the universe."

A few months later, astronomers at Lick Observatory in California found a redshift of 3.53 for another Ohio State radio source, OQ172. "Those sources were the most distant known objects for at least a dozen years," says Kraus. "There had been predictions that such high redshifts would never be found, so that was really startling. The higher redshifts that are being found now are moving the edge back just a percent or two. OH471 was the quantum leap."

LISTENING FOR LIFE

Even though the Ohio State survey covered 70 percent of the sky, mapped almost 20,000 radio sources, and led to scores of technical papers, the National Science Foundation cut off funding in 1973. What could Kraus and company do for an encore? Kraus's colleague Robert Dixon suggested that Big Ear could begin searching for intelligent life in the universe, an idea that seized Kraus's imagination. "My attitude about SETI is very simple and objective," says Kraus. "Either we're alone or we're not, and either way is simply a mind-boggling concept. If we want to find out, we need to do some observational work."

Ohio State's SETI program began on December 7, 1973, and ran continuously until September 1997, making it the longest running SETI program in history. "Throughout the search, John was always there whenever needed to help with technical and political problems and to lend his critical astronomical insights," says Dixon.

As midnight approached on August 17, 1977, Big Ear picked up a powerful signal from deep space that lasted for 37 seconds. There were no spacecraft in the direction of the signal. The signal was intermittent and confined to a single channel — just the kind of beacon that one would expect from a communicative civilization. In contrast, natural sources generally emit much fainter radio signals that remain constant for days or years on end and are smeared over thousands of channels.

If Ohio State had 1990's high-tech equipment, it could have better tracked and understood this Wow! signal. But there has never been another one. As Cornell University radio astronomer James Cordes says, "It could have been a combination of the real thing, but influenced strongly by scintillation effects, or it could have been interference." Kraus adds, "All one can say is that it's not possible to give an answer, yes or no. It could have been a signal from an extraterrestrial civilization that was sweeping by, and we just happened to catch it. But because it hasn't returned, we could not study it further. So unless the signal comes back again, we can only wait and wonder."

Big Ear's search for ET and the tantalizing Wow! signal convinced Kraus that the time had come for a serious magazine devoted to the issue of extraterrestrial life. In 1979, Kraus spent $40,000 of his own money to launch *Cosmic Search* and countless hours printing and selling it. But public interest was limited. After three years and 13 issues of low sales and financial losses, Kraus pulled the plug.

THE END OF BIG EAR

Without the theories of Scottish physicist James Clerk Maxwell, we might never have had the radio telescope Big Ear. Maxwell's theories of electromagnetism led to the discovery of radio waves. Unfortunately for Big Ear, the Scots also gave us golf. And in 1983, Ohio Wesleyan University sold the land underneath Big Ear to a developer who planned to expand a golf course from 9 to 18 holes. For 15 years, Big Ear was reprieved, but the stay of execution ended on January 1, 1998. The telescope has been demolished, and golfers will soon be teeing up where astronomers once peered 12 billion light-years into the past.

Kraus has forgiven Ohio Wesleyan, an institution to which he and Alice have donated a wilderness tract and a $60,000 endowment. "The way I feel, it's over, it's history, and that's that. Big Ear's accomplishments will live on," he says.

Still, Kraus laments the priorities that led to Big Ear's demise. "We opened a window on the universe and now it has been slammed shut. In a confrontation between the galaxy and golf, golf won. We had 750 golf courses in Ohio. Now we have one more. And the Midwest has gone from one radio telescope to zero. Big Ear discovered objects at the edge of the universe, and now it's a putting green."

Doug McInnis is a freelance science writer based in Casper, Wyoming. His previous article for Astronomy *was "Wanted: Life-Bearing Planets," which ran in the April 1998 issue.*

THE SKY SHOW

Long days and warm nights offer stargazers the opportunity to observe around the clock.

by Martin Ratcliffe and Alister Ling

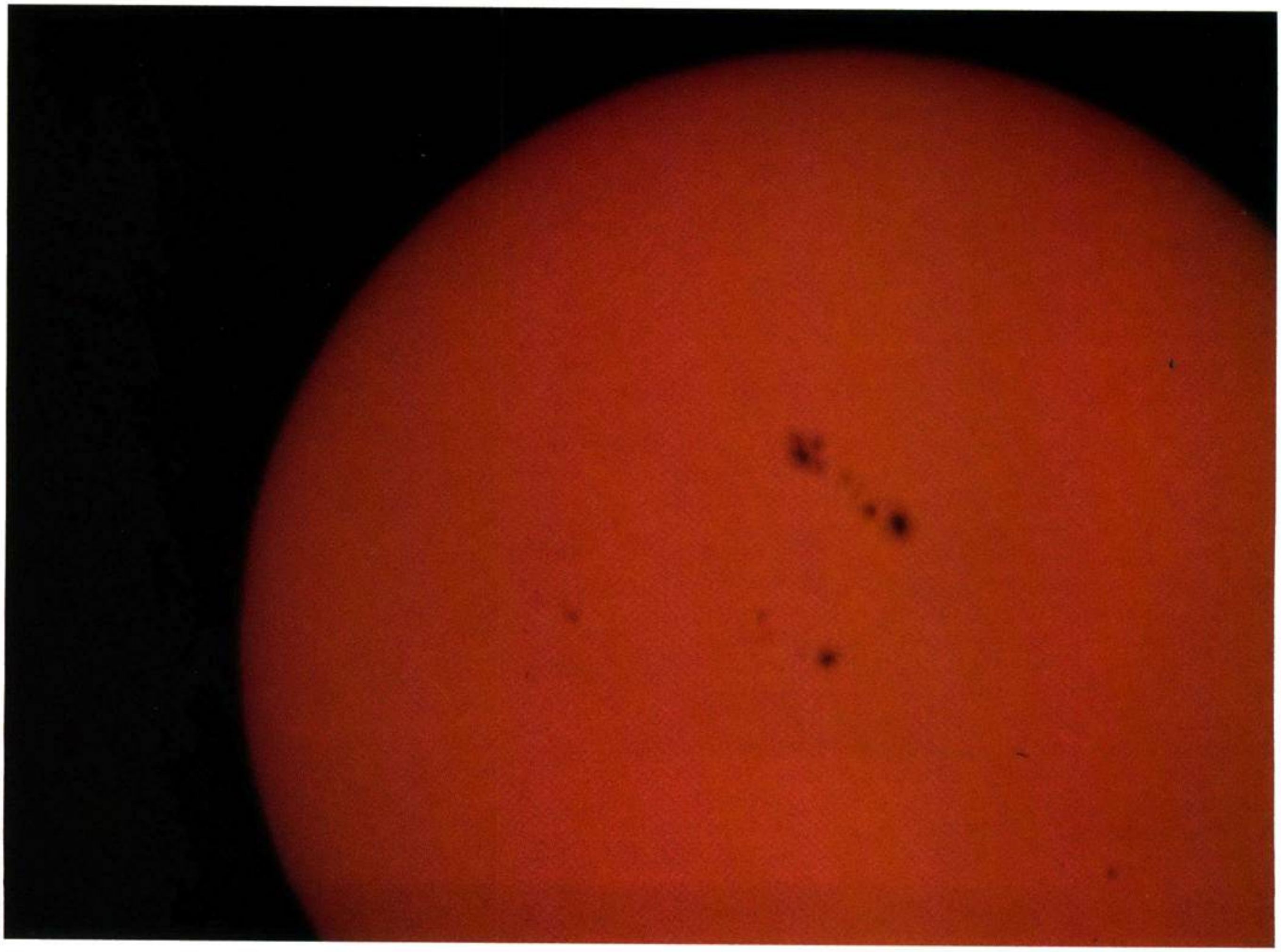
Have you ever wondered what the surface of a star looks like? If so, look no further than our own sun. This month provides plenty of opportunity to observe our daytime star with the longest day of the year (June 21) and the latest sunset (June 27) both occurring in the Northern Hemisphere. Only one word of warning: Make sure adequate safety precautions are taken. Use an approved solar filter that covers the large aperture of the telescope. Only then can an observer view the wonderful, ever-changing myriad of sunspots, which hint at the dynamic activity below.

Our star bubbles like a large pot of thick chili. Seething hot gases well up from deep within, rising quickly in columns 500 miles across only to cool and fall back to the surface. This creates a granulation effect that is visible in small telescopes. If an unseen cluster of magnetic field lines impedes this outflow of energy, the surface cools by a thousand degrees or so, making the region look dark in contrast to its hotter surroundings. These cooler regions are the sunspots.

Drawings of sunspot positions done each day reveal, on average, a 25-day rotation of the sun. As the period of maximum solar activity nears during the next few years, dozens of new sunspots are expected to erupt. Many of the larger ones will change their appearance significantly from day to day. Observing these changes is rewarding and fun.

Once the sun sets, rather late in June, the sky slowly darkens. Springtime constellations such as Cancer, Leo, and Virgo can be found to the west of the central meridian (an imaginary line running north-south, though the zenith, dividing the sky into a western and eastern half). The stunning orange

Dust off those solar filters and start watching the sun. Our star is moving toward its eleven-year maximum, and that means more sunspots, solar flares, and prominences to observe.



John Chumak

JUNE 1999

3 The moon passes 0.7° north of Neptune, 6 P.M. EDT

4 The moon passes 0.5° north of Uranus, 6 P.M. EDT

5 Mars is stationary, 3 A.M. EDT

7 Last quarter moon is at 12:20 A.M. EDT

9 The moon passes 4° south of Jupiter, 8 P.M. EDT

10 The moon passes 3° south of Saturn, 10 P.M. EDT

11 Venus is at greatest eastern elongation (45°), 8 A.M. EDT

12 The moon is at perigee (222,570 miles from Earth), 8:39 P.M. EDT

13 New moon is at 3:03 P.M. EDT

15 The moon passes 4° south of Mercury, 4 A.M. EDT

16 The moon passes 2° south of Venus, 11 P.M. EDT

18 The moon passes 1° north of Regulus, 7 A.M. EDT

20 First quarter moon is at 2:13 P.M. EDT

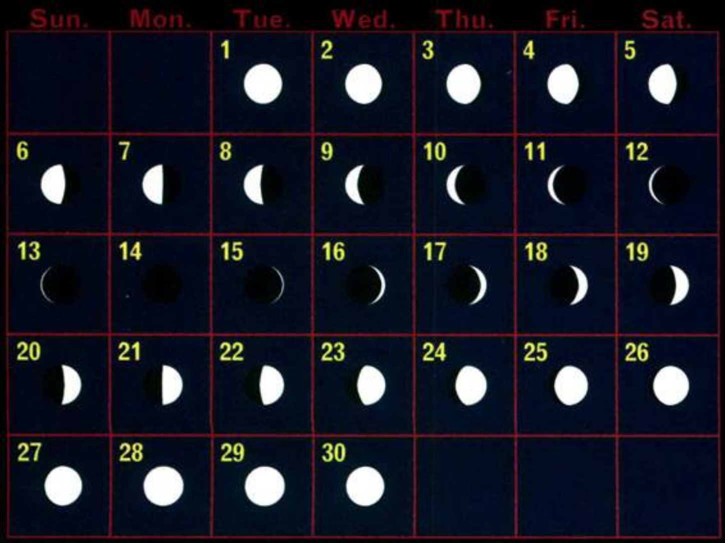
21 Mercury passes 5° south of Pollux, 2 P.M. EDT
Summer solstice is at 3:49 P.M. EDT

22 The moon passes 6° north of Mars, 4 P.M. EDT

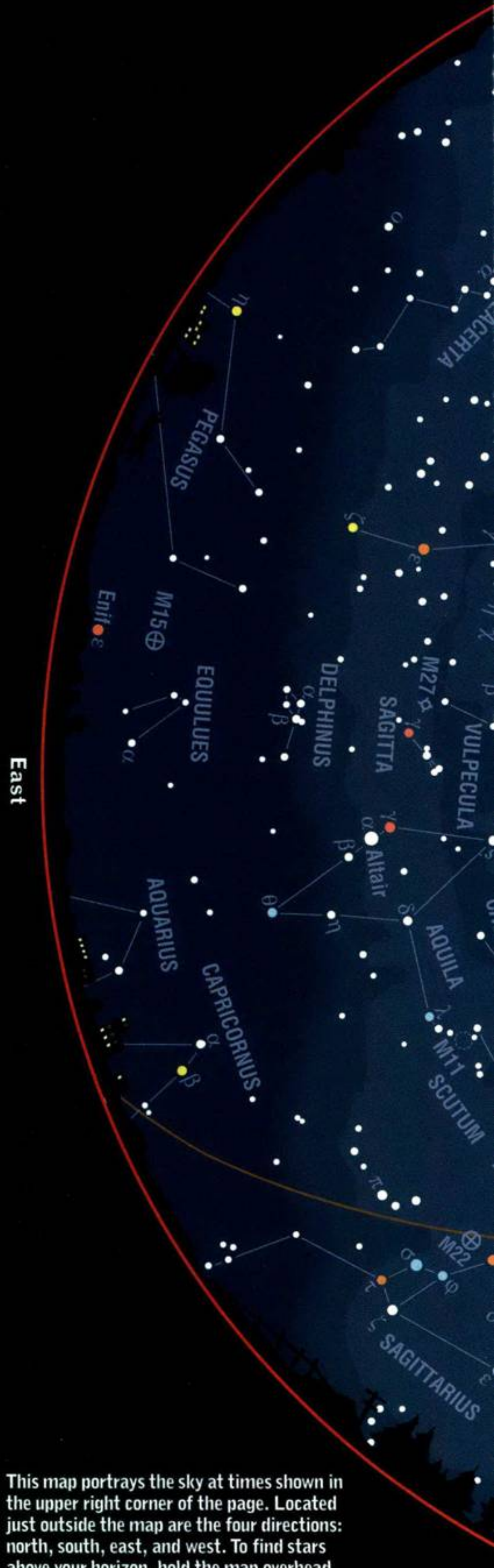
25 The moon is at apogee (252,189 miles from Earth), 11:32 A.M. EDT

28 Full moon is at 5:37 P.M. EDT
Mercury is at greatest eastern elongation (26°), 7 P.M. EDT

30 The moon passes 0.6° north of Neptune, 11 P.M. EDT



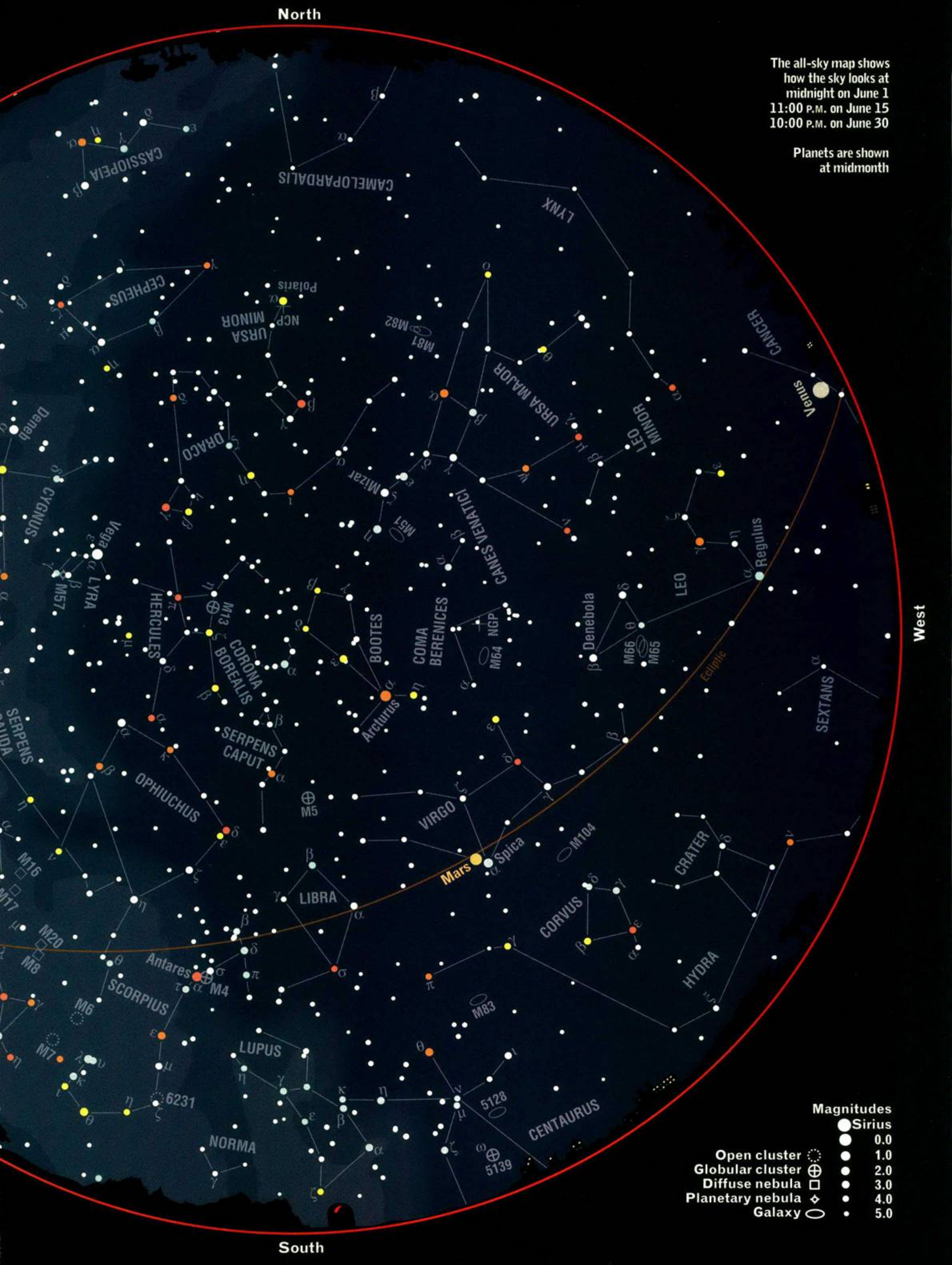
Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			



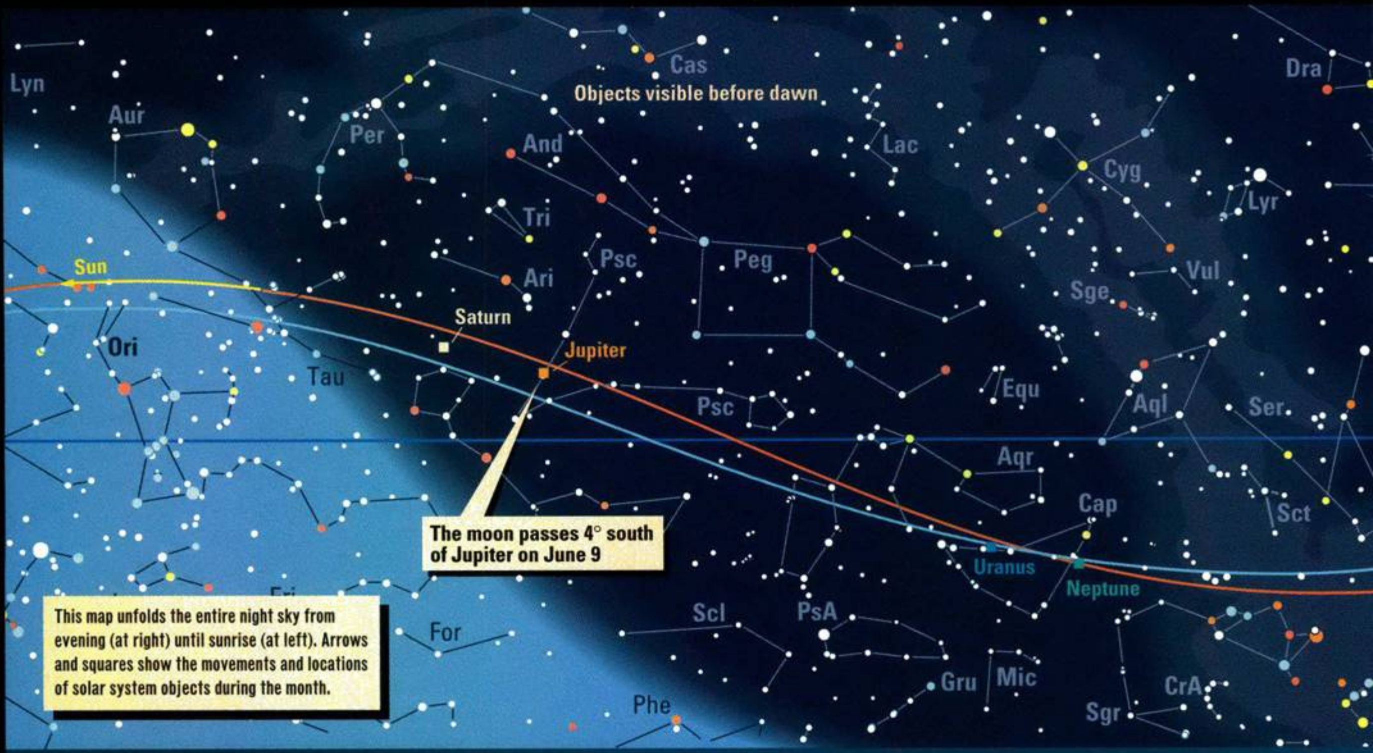
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows
how the sky looks at
midnight on June 1
11:00 P.M. on June 15
10:00 P.M. on June 30

Planets are shown
at midmonth


North
West
South
CASSIOPEIA
CAMELOPARDALIS
LYNX
CEPHEUS
Polaris
NCP
URSA MINOR
M82
M81
URSA MAJOR
CANCER
Venus
LEO MINOR
DRACO
Deneb
Mizar
M51
CANES VENATICI
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
M64
Denebola
M66
M65
LEO
Regulus
Ecliptic
Arcturus
SERPENS CAUDA
SERPENS CAPUT
OPHIUCHUS
M5
VIRGO
SEXTANS
M104
Spica
Mars
LIBRA
CRATER
CORVUS
M16
M17
M20
M8
Antares
M4
SCORPIUS
M6
M7
HYDRA
M83
LUPUS
6231
5128
CENTAURUS
NORMA
5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS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Aur
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Objects visible before dawn
And
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Tri
Psc
Peg
Ari
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Vul
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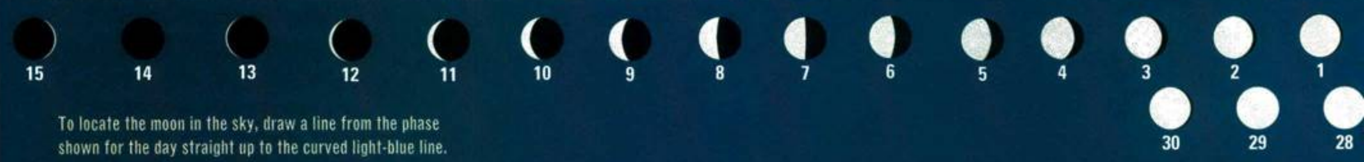
Saturn
Jupiter
Ori
Tau
Psc
Equ
Aql
Ser
Aqr
Cap
Sct
Uranus
Neptune
Eri
For
Scl
PsA
Gru
Mic
CrA
Phe
Sgr

The moon passes 4° south of Jupiter on June 9

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.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To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

10"

S

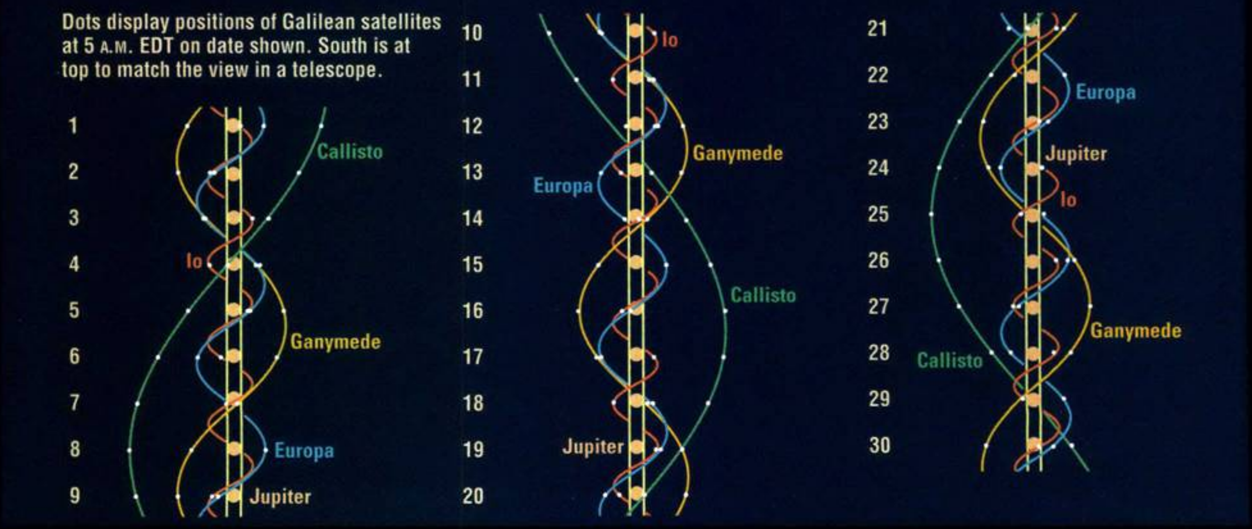
W E

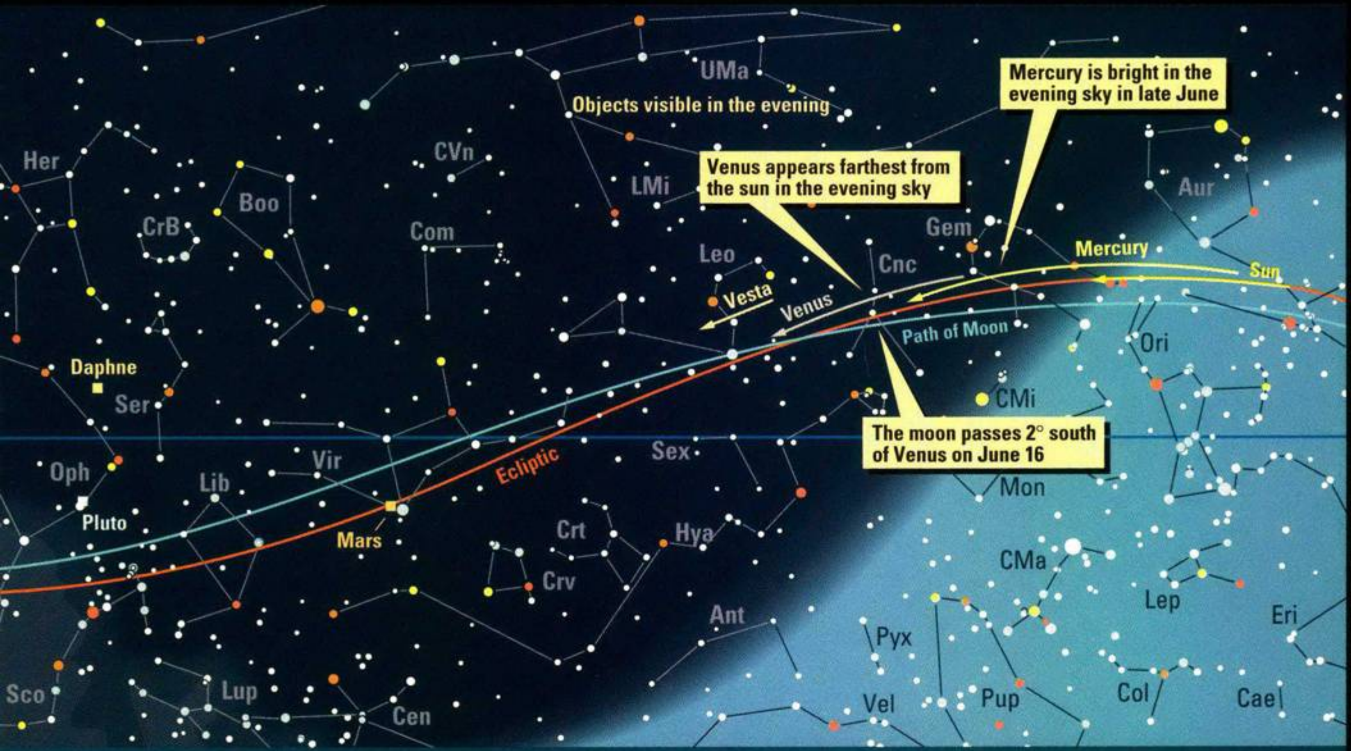
N

PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	June 15	June 30	June 1	June 30	June 1
Magnitude	−0.3	0.6	−4.2	−4.4	−1.1
Angular Size	6.3"	8.3"	21.0"	29.8"	14.3"
Illumination	66%	38%	55%	38%	94%
Distance (AU) from Earth	1.072	0.812	0.793	0.560	0.654
Distance (AU) from Sun	0.382	0.450	0.721	0.725	1.544
Right Ascension (2000.0)	7h02.8m	8h22.6m	7h50.1m	9h37.2m	13h30.5m
Declination (2000.0)	24°39'	19°30'	23°41'	15°06'	−9°43'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 5 A.M. EDT on date shown. South is at top to match the view in a telescope.





UMa
Objects visible in the evening
Mercury is bright in the evening sky in late June
Her
CVn
LMi
Venus appears farthest from the sun in the evening sky
Aur
Boo
CrB
Com
Gem
Mercury
Leo
Cnc
Sun
Vesta
Venus
Path of Moon
Ori
Daphne
Ser
CMi
The moon passes 2° south of Venus on June 16
Oph
Vir
Sex
Ecliptic
Lib
Mon
Pluto
Mars
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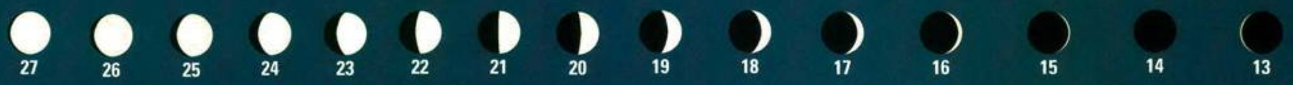
Cen
Vel
Pup
Col
Cae



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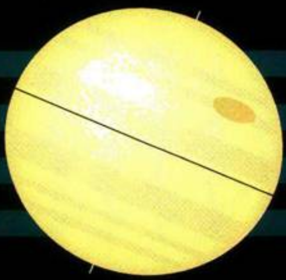
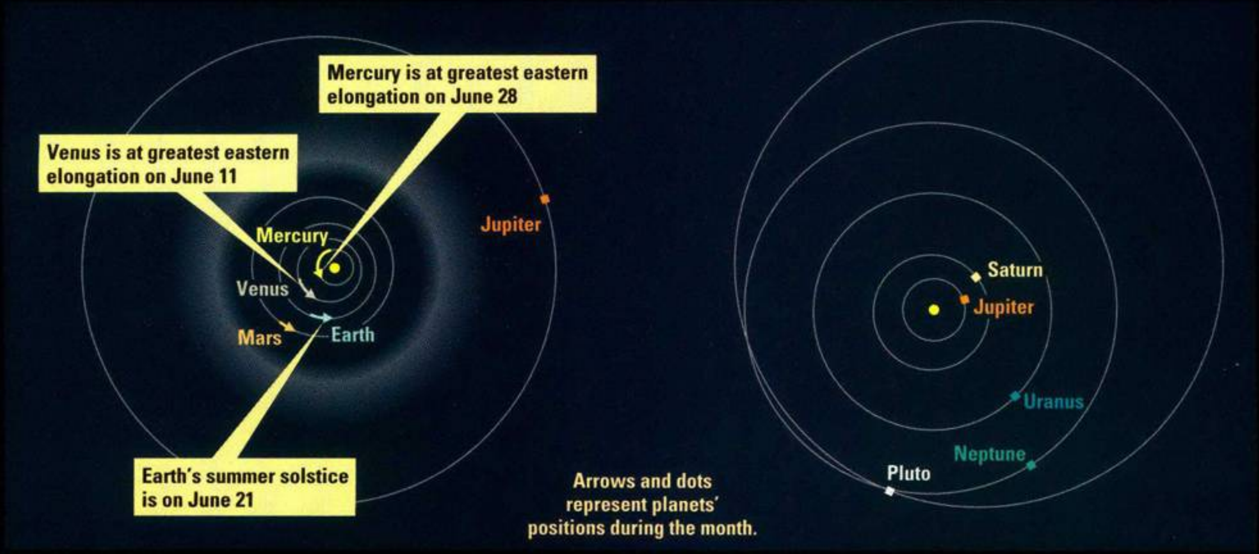


MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
June 30	June 15	June 15	June 15	June 15	June 15
−0.5	−2.2	0.4	5.7	7.9	13.7
11.6"	36.2"	16.7"	3.7"	2.3"	0.1"
89%	99%	100%	100%	100%	100%
0.810	5.450	9.973	19.277	29.348	29.203
1.507	4.951	9.229	19.904	30.128	30.166
13h44.0m	1h44.7m	2h43.5m	21h17.0m	20h25.0m	16h35.5m
−11°54'	9°34'	13°31'	−16°32'	−18°59'	−10°03'

THE PLANETS IN THEIR ORBITS



Mercury is at greatest eastern elongation on June 28
Venus is at greatest eastern elongation on June 11
Jupiter
Mercury
Venus
Mars
Earth
Earth's summer solstice is on June 21
Saturn
Jupiter
Uranus
Neptune
Pluto

Arrows and dots represent planets' positions during the month.

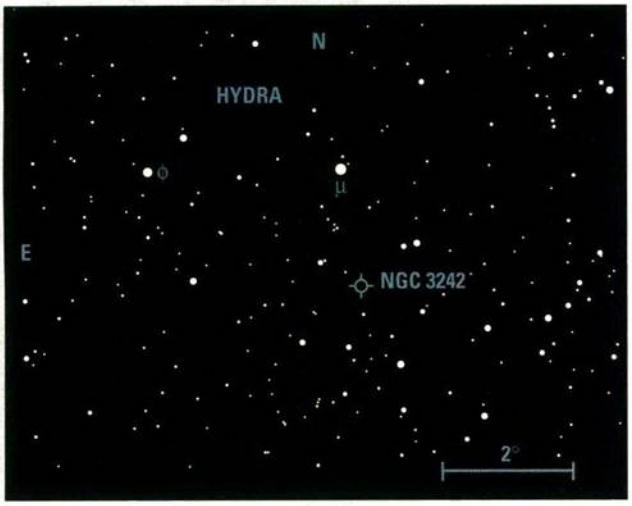
FIRST VIEWS: The Ghost of Jupiter

Striking is one word that comes to mind when viewing NGC 3242, and with a name like the Ghost of Jupiter, you know it has a legacy.

The great British astronomer William Herschel viewed this gaseous puffball on February 1, 1784 — by which time he had already coined the descriptive term "planetary nebula." He applied the term to those small, round clouds that reminded him of his earlier major discovery, the planet Uranus. He described this object as a "beautiful, brilliant planetary disk ill defined, but uniformly bright, the light of the colour of Jupiter."

With nearly the same angular size as Jupiter, NGC 3242 is readily visibile with a 4-inch telescope under dark skies. It also yields modestly to an 8-inch scope through the suburban veil of light. A nebula filter makes the 8th-magnitude object an easy target. One wonders how comet hunter Charles Messier missed it.

James McGaha



All illustrations *Astronomy*: Elisabeth Rowan

Remember that small objects such as planetaries can withstand a lot of magnification, so boost it up past 200x. At such magnifications, an eye-shaped glow should come into view. If your telescope is 8 inches or larger, shield your eyes or use a dark hood to pull the roundish outer halo (at 40") into view.

If you have setting circles, zero in at 10h24.8m –18°38' (2000). Otherwise, you'll likely need binoculars to hop your way along the zigzag tail of Hydra. This may seem cumbersome, but it's well worth the effort!

star Arcturus competes for attention with nearby **Mars** to its south. Farther south and east of Arcturus is the "rival of Mars," Antares. Watch the Red Planet's motions as it will meet its rival in late September.

The Big Dipper begins its long and slow fall to the northwest. Its large ladle shape cartwheels ever so gently around the 2nd-magnitude pole star, Polaris.

The Big Dipper's parent constellation, Ursa Major the Great Bear, is also easily spotted. The handle of the dipper marks the tail of the bear, while the bottom of the dipper's cup marks the stomach of the bear. Ursa Major lies overhead in the early evening, but is soon replaced — first by Boötes the Herdsman and then by Hercules an hour later.

Hercules passes directly overhead shortly after 10 P.M. local time in early June. Look for its splendid globular cluster, M13. Sit back in your lawn chair with a pair of binoculars and the sky dome map. You'll find it quite easily.

By late evening, the drama of the summer sky holds court for observers in dark locations. The Milky Way is rising in the eastern half of the sky. The summer triangle, formed by Deneb in Cygnus, Vega in Lyra, and Altair in Aquila, echoes the oncoming season for country and city dwellers alike.

The most obvious object in the sky, apart from the moon, is **Venus**. This second planet from the sun is a brilliant "star" visible in the western sky shortly after sunset. It reaches greatest elongation from the sun (45.4° east) on June 11. The planet's distance from Earth is shrinking, which causes a slight increase in its brightness: from magnitude –4.2 to –4.4. Observers can also watch the disk grow an incredible 9" during the month. The planet's disk is at 21" across on June 1 with a slight gibbous phase predicted to be 55-percent illuminated. When does Venus reach exactly 50-percent illumination, or dichotomy? June 10 is the predicted date, but often this moment occurs early. Determining the exact time that the terminator of Venus is perfectly straight is rather difficult. It is best attempted when the planet is situated in a brighter daytime sky rather than the high contrast of dusk.

Following its year-long climb in the evening sky, Venus begins to fall quickly in altitude after the month passes. By mid-August it will be lost in the solar glare. In the meantime, watch Venus glide through the northern section of the Beehive Cluster (M44 in Cancer) on June 12 and 13. A slender crescent moon joins the evening star on June 16, passing 3° below the planet.

During late June **Mercury** climbs away from the sun for a brief evening appearance. This is one of the best times to view Mercury this year. It also reaches 50-percent illumination this month, on or around June 23. Try comparing the view of Mercury with Venus.

Grab a pair of binoculars to find 3rd-magnitude Epsilon (ε) Geminorum just one moon's-breadth above Mercury on June 10. Observers in Asia might see them even closer — a mere 41" apart at 10h Universal Time. Five days later the crescent moon forms an almost perfect equilateral triangle with the bright star Pollux and magnitude –0.2 Mercury. The planet continues to move away from the sun and appears in a line with Castor and Pollux, the pair of bright stars in Gemini, on June 24. On this night, Mercury stands 10° above the western horizon 45 minutes after sunset. On June 28, it reaches its greatest elongation east (25.5°) of the sun.

More than a month has passed since the Red Planet, Mars, was at opposition. It now appears almost motionless relative to the star Spica. Their contrasting colors and close proximity (less than 5° all month long) draw attention to the constellation Virgo where Mars has taken up residence.

The Return of the King

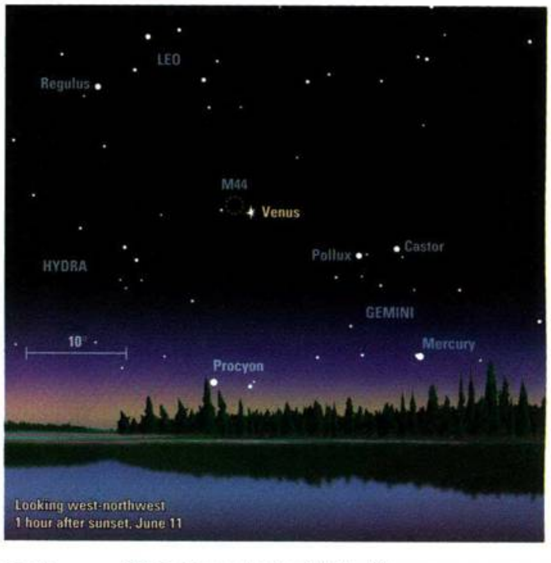
After a spring hideaway behind the sun, Jupiter returns to the morning sky. Remember the wonderful cloud top activity seen last autumn? Let's hope for more this year. Among the fascinating events seen last year was a darkening inside the Great Red Spot. Has the Red Spot returned to full bloom after two decades of pale color, or was it just teasing us? The best way to find out is to look for yourself.

Charles F. Capen

Though summer mornings come early at northern latitudes, many among us will rise just to see Jupiter. The planet lies due east as dawn brightens the sky. It hangs roughly 10° above the horizon, the width of a fist held at arm's length. Can you spot Saturn? It is to the lower left of Jupiter. You may need binoculars to find them at the start of the month. Watch how each planet continues to close in on the other as the year progresses.

The Evening Diva

Ever since its reappearance in January, Venus has rightfully captured our attention as it lights the evening sky. The planet is approaching its greatest eastern elongation from the sun on June 11. Its shape is a fat half-moon disk shining at magnitude –4.2. From our earthly point of view, Venus appears to be at its farthest point east of the sun on June 11. After this date, the planet will appear to move westward back toward the horizon and the setting sun. The orbits of Venus and Mercury keep them close to the sun in our sky. For that reason, these inner worlds can never be seen late at night.



Looking west-northwest
1 hour after sunset, June 11

As you wait for Mercury and the moon to reappear later this month, use your binoculars to spy M44, the Beehive Cluster, 11° (1.5 binocular fields) to the upper left on June 1. Allow twilight's glow to fade in order to see the large group of stars. In less than two weeks, Venus will graze through M44's northern fringe.

The speed at which Mercury moves relative to the background stars never ceases to amaze me. Its phase by mid-month is less than 50-percent lit. Watch for the bright three-day-old crescent moon to photogenically slide half a binocular field below Venus on the evening of June 16.

Moons in June

It's easy to notice a summertime moon because we're more likely to be outside enjoying longer daylight hours and warm evenings. While you sit on a park bench contemplating the view, take note of the moon's phase. On Wednesday, May 26, the moon sits not far from Mars and Spica — a couple of days before full.

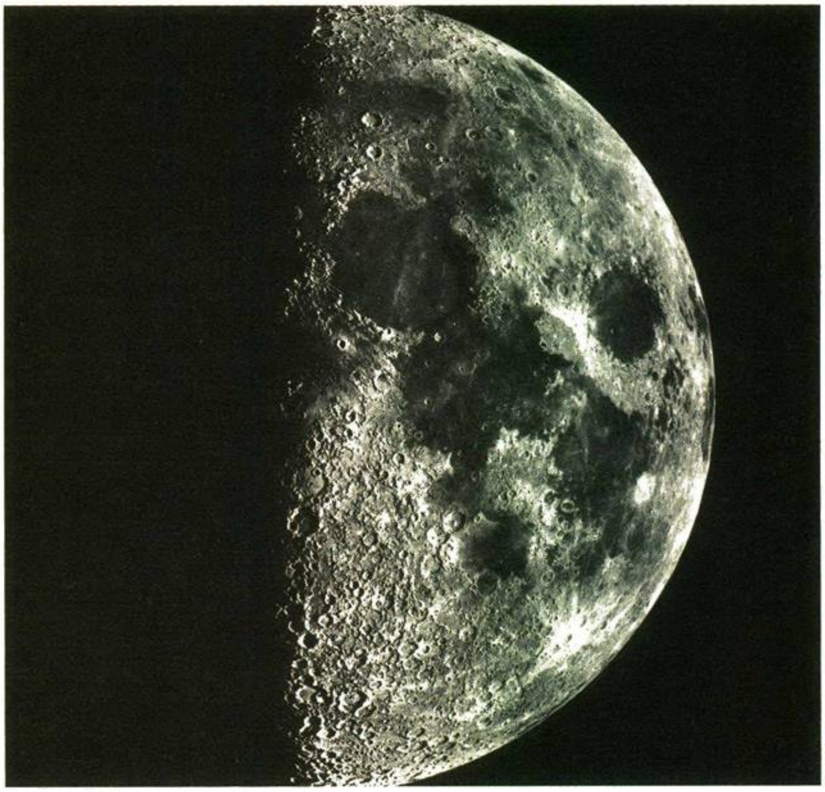
The next time the moon passes this twosome is June 22. On that date its phase is just past first quarter. This difference in phase from one month to the next is the result the moon's 27.3-day sidereal (with respect to the stars) orbit around Earth. Through the course of a sidereal lunar month, Earth moves a fair distance around the the sun, and it takes the moon with it. This means the moon needs another couple of days to move back into its previous alignment with the sun and Earth — the more familiar 29.5 day synodic (with respect to the sun) lunar month.

Take a close look at the crescent moon on June 16 or 17. The large dark eye of Mare Crisium sits comfortably away from the lunar limb (at roughly 3 o'clock in the photos). At full moon on June 28, Crisium is almost skirting the edge. This small change in position is called libration.

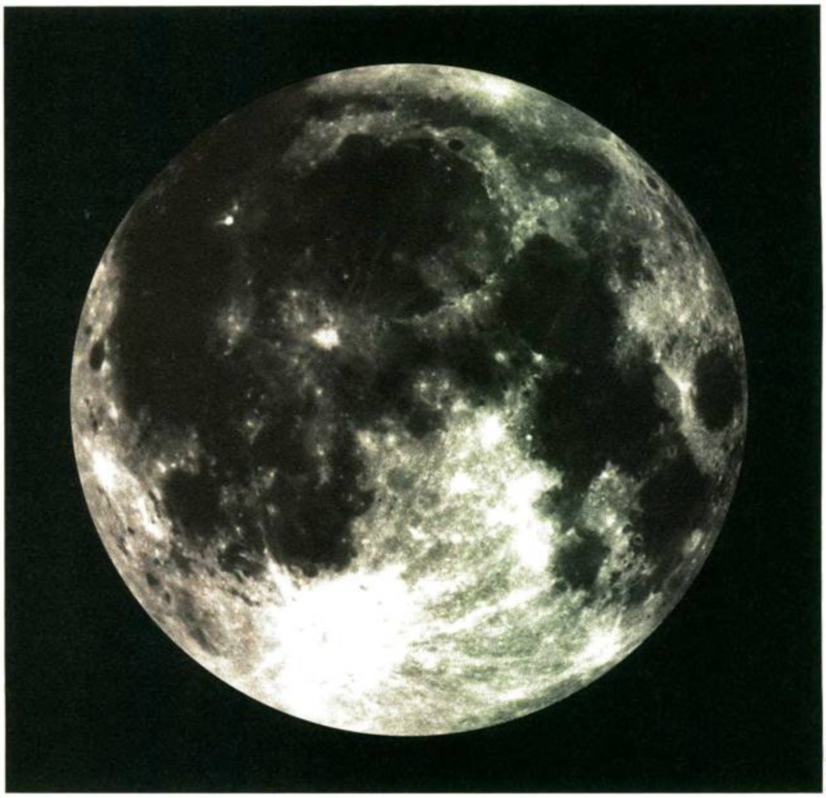
As the moon travels along in its elliptical orbit around Earth, it speeds up and slows down. This slight difference in the moon's orbital rate causes libration. Though the difference is quite small, it does allow an observer on Earth to see slightly more than one hemisphere of the moon over a given period of time.

When the moon is at its farthest point away from Earth (apogee) it moves around Earth a bit slower than it spins. This provides Earthly observers with the opportunity to glimpse around and see a bit more of the moon's leading edge. When the moon is at its closest point to Earth (perigee), its orbital motion is slightly faster than its spin. At that time, observers get a peek behind the trailing edge of the moon.

Libration is an easy phenomenon to follow. Use a small telescope or binoculars to get a closer view.



Lick Observatory



Bob Sandy

Earliest Sunrise and Latest Sunset

You would think that the Northern Hemisphere's longest day of the year would also boast the earliest sunrise and the latest sunset, but the tilt of Earth's axis puts a spin on this case.

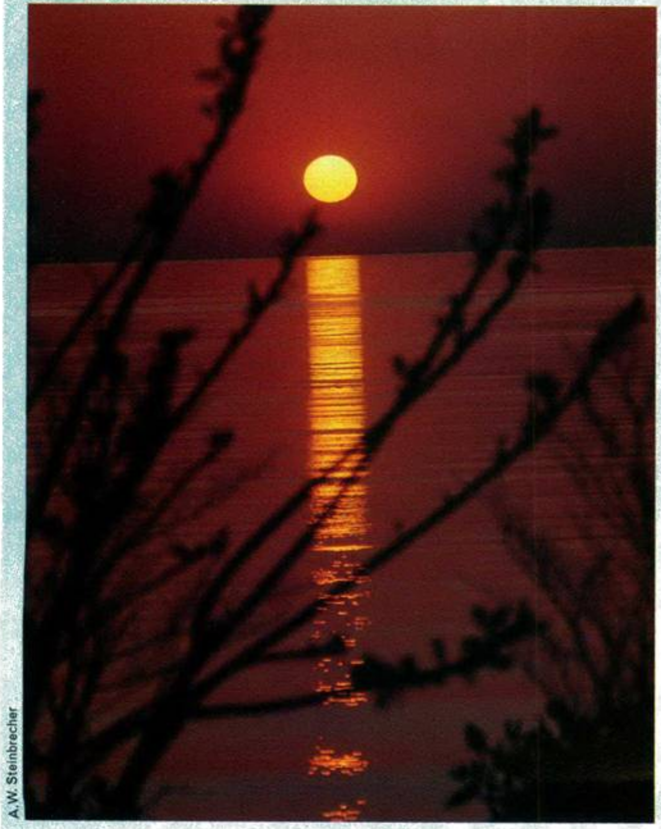
Earth turns on its axis in roughly 23 hours and 56 minutes. In that amount of time, the planet has moved along its orbit and changed its angle with respect to the sun enough to need four extra minutes of spinning to bring the sun back in line. Those four minutes represent the difference between the sidereal day (the day as measured with respect to the stars) and the solar day (the day as measured with respect to the sun).

The sun appears to move roughly 1° per day with respect to the distant stars. This apparent movement is caused by Earth's 360° orbit around the sun in 365 days. That 1° per day is equivalent to 4 minutes of right ascension at the equator (a one-day [360°] rotation is equivalent to 24 hours of right ascension).

Picture lines of longitude dividing Earth into 24 one-hour time zones. Because Earth is a sphere, these zones bunch up as you move away from the equator toward the poles. At the summer solstice, Earth's northern axis is tilted toward the sun. The sun's rays hit the Northern Hemisphere more directly and the sun appears to be farther north in the sky. It moves across those "time zones" faster than it would if the sun were directly over the equator. Both sunrises and sunsets become later than scheduled.

EARLIEST SUNRISE AND LATEST SUNSET

NORTH LATITUDE	EARLIEST SUNRISE	LATEST SUNSET
20°	June 6	July 5
25°	June 9	July 3
30°	June 11	July 1
35°	June 13	June 29
40°	June 14	June 28
45°	June 16	June 26
50°	June 17	June 25
55°	June 18	June 24
60°	June 19	June 23



A.W. Steinbrecher

Sunsets continue to get later for a week or so after the solstice. Before June 21, the sun is still moving toward later sunrises. So why is the sunrise earlier? Between the spring equinox and early May, the sun accumulates time and is a bit ahead of schedule. After the equinox this "extra time" is gradually eroded by the "time zone" effect. The result, just before the solstice, is that the sun is barely ahead of schedule. We see this as an earlier sunrise by a minute or two. Now you know why we use mean solar time and not local solar time.

Sundial folk have developed a way to know when and how much the sun is ahead or behind schedule. This method is called the "equation of time." Unless you use a sundial, you wouldn't really notice the effect. The ever-changing length of day, thanks to Earth's tilt, really masks the slower changes of being ahead or behind schedule. It's only noticeable for the couple of weeks around the winter and summer solstices. This equation of time business shows up as an "8" printed on globes of Earth, as well as in the pretty figure 8 analemma seen in multiple exposure photographs.

One last point in this compressed introduction. Earth's orbit is elliptical, something we ignored up to this point. Because Earth's orbit isn't a perfect circle, the planet moves faster at perihelion (closest point to the sun) and slower at aphelion (farthest point from the sun). This adds a twist to the equation of time. Though measurable, the effect is not large enough to factor into the broad-based discussion above. If you're fascinated with timekeeping, find a book on sundials and start reading.

Mars ends its retrograde path against the stars on June 5, when it begins once again to move eastward away from Spica. The closest the Red Planet appears to get to Spica is 1.7° on June 9. Mars shines two magnitudes brighter than its –0.9-magnitude stellar neighbor. The planet lies high in the south-southwestern sky right after sunset. Its obvious orange hue signals its identity. Mars will begin to shrink fast. In early June, the planet is still more than 14" across, but it sheds 2" by June 30.

Pluto is a far tougher challenge at magnitude 13.7. It's moving due north of Zeta (ζ) Ophiuchi, which lies midway along the base of the kite-shaped constellation Ophiuchus. Pluto reached opposition on May 31 and is best spotted by noticing its slow nightly movement to the west relative to the stars. You'll need an atlas that shows stars down to magnitude 14 and a telescope with a minimum aperture of 8 inches.

Tumbling between the orbits of Mars and **Jupiter** are the asteroids. Tracking them down is a hobby enjoyed by many. Try finding three of the brighter ones. Minor planet 3 Juno lies less than a degree northwest of Delta (δ) Ophiuchi in the lower right hand corner of Ophiuchus. The dim asteroid reached opposition on May 25 and shines at magnitude 10.2. During June, it moves quickly west among the stars of Serpens Caput. ■

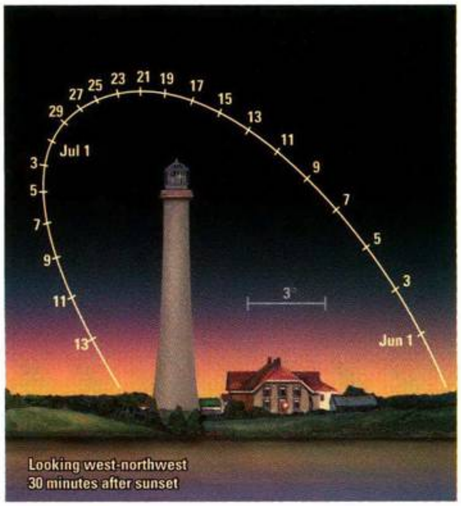
Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

Mercury the Swift

There's no doubt why the ancients gave Mercury its fleet-footed name — the planet appears then disappears in less than a month. This month provides its best show of the summer, if you know when and where to look.

Begin your search on June 11, when Mercury shines at magnitude –0.5 (40 times fainter than Venus). Wait until the bright twilight colors have begun to fade before beginning your search. By this time, the small, airless planet will be within one binocular field of the horizon — roughly 6° up and almost halfway between Venus on the left and Capella on the right.

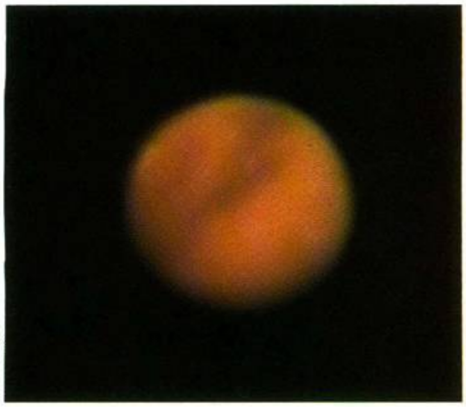
The thin crescent moon shows up on June 15, roughly 10° to the left. If you don't have a viewing site with an uncluttered horizon, it's worth the effort to find one. If you live in a city, head for the southeast side and look for a park with a view of the downtown — or try an apartment rooftop.



Looking west-northwest
30 minutes after sunset

Mercury reaches its highest altitude on June 17, but a week later it will have faded 1 magnitude and be sporting a thinning half-moon figure. As July begins, Mercury has almost succumbed to the horizon's bright glow.

Mars at Center Stage


Mark Hodges

Have you done a "double take," as I have, thinking the Mars-Spica pair is a bright double nova? Each night I eagerly await sunset, hoping for steady skies that will let me observe Mars's magnificent surface.

One of the best times to observe planetary details is right after sunset. Typically, the lower atmosphere is well mixed at that time of day. The bubbles of different air density have been dispersed, which improves the "seeing." At nightfall, cooling sets in and Earth gives up the solar heat gathered during the day. This energy is released in large turbulent wafts that cause shimmering and occasionally bouncing images.

Though Mars is moving away from Earth, its shrinking diameter is still larger than at its closest approach in 1997. Increase the magnification to the sky's limit, which will provide a better look at the planet's dark surface blotches. Will there be a sand storm in progress? Perhaps. If so, familiar features will be invisible, or a certain area will appear to be much brighter than it was a week ago. How small is the polar ice cap? A view of Mars through the eyepiece provides an observer with plenty to see.

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MTS-SN6 Telescope	CALL

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CELESTRON

SCHMIDT-CASSEGRAINS

C5+

For astronomy on the go, the C5+ can't be beat. Due to its excellent Schmidt-Cassegrain design and careful crafting, the telescope is a serious, high performance instrument, and its compact size makes it totally portable. The total weight of the C5+, with wedge, is just 23lbs., making it easy to transport.

The C5+ is made in the USA and features Celestron's legendary hand-figured, diffraction limited optical system for optical performance you can depend on. The reputation for excellence of this telescope is such that it was chosen by NASA, over all other competitive models, for several recent space shuttle missions.

C5+ 5", 1250mm f/10	**CALL ***
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ULTIMA 9 1/4 9 1/4", 2350mm f/10	**CALL ***
Ultima 11 11", 2800mm f/10	**CALL ***
CG 9 1/4 w/Losmandy Mount	**CALL ***
CM-1100 11", 2800mm f/10	**CALL ***
CM-1400 14", 3910mm f/11	**CALL ***
G-3 3.5", 1000mm f/11 **NEW!**	**$499.00**
G-5 5", 1250mm f/10 **NEW!**	**$689.00**
G-8 8", 2032mm f/10 **NEW!**	**$999.00**

CELESTAR 8 COMPUTERIZED

Engineered for unsurpassed optical performance in an affordable, full featured Schmidt-Cassergrain telescope of large enough apeture to do serious deep-sky observing. This telescope is carefully crafted and manufactured in the USA for dependable quality of the highest caliber. It offers the lowest price ever for a Celestron fork mounted 8" telescope.

The Celestar 8 Computerized comes with factory installed and tested Advanced Astro Master. The Advanced Astro Master pointing system contains a database of over 10,000 objects. Once aligned, it will guide you to any one of these objects.

CELESTAR 8 8", 2032mm f/10	**CALL ****
CELESTAR 8 COMPUTERIZED	**CALL ****
CELESTAR 8 DELUXE	**CALL ****
CELESTAR 8 DLX COMP.	**CALL ****

* FREE! 2x BARLOW W/PURCHASE

STAR HOPPER DOBSONIAN

4.5"	CALL	11"	CALL
6"	CALL	14"	CALL
8"	CALL	17.5"	CALL

FREE GIFT WITH DOBSONIAN PURCHASE!

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KIT #1 Includes: 5x24 Finderscope, 10mm SMA Eyepiece, Moon Filter & *"The Sky for Celestron"* CD-ROM	CALL
KIT #2 Includes: 6x30 Finderscope, 10mm SMA Eyepiece, Moon Filter, LED Flashlight & Celestron Sky Maps	CALL
KIT #3 Includes: 9x50 Finderscope, 7.5mm & 17mm Plossl Eyepiece, Moon Filter, Night Vision Flashlight & *"The Sky for Celestron"* CD-ROM	CALL

NEWTONIAN TELESCOPES

Firstscope 76 Series 76mm (3")	**CALL ****
Firstscope 114 Series 114mm (4.5")	**CALL ****
C114-HD 114mm (4.5"), 900mm f/8	**CALL ****
C150-HD 150mm (6"), 1000mm f/7	**CALL ****

REFRACTOR TELESCOPES

Firstscope 80 Series 80mm (3.1")	**CALL ****
Firstscope 70 Series 70mm (2.8")	**CALL ****
Firstscope 60 Series 60mm (2.4")	**CALL ****
C80-HD 80mm (3.1"), 900mm f/11	**CALL ****
C102-AZ or HD 102mm (4"), 1000mm f/10	**CALL ****

SPOTTING SCOPES

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Ultima 80	**$349.00**
Rich Field 80	**$299.00**
60mm Zoom	**CALL**
50mm Zoom	**CALL**
30mm Mini Spotter	**$79.00**

TRIPODS & MOUNTS

Lightweight Field Tripod (93591-A)			179
Photographic Slow Motion Control			26.95
Photographic Slow Motion Control Deluxe			57.95
Photographic Tripod (93596)	99.95	Vibration Supression Pads	39.95
Heavy Duty Wedge (93655)	239.95	Upgrade Kit f/93655	114.95

ASTRO/CCD PHOTOGRAPHY

CCD Camera PixCel	CALL	Piggyback Mount 8" & 9 1/4"	34.95
CCD Color Filter Wheel	364.95	Radial Guider	98
Digital Setting Circles	CALL	Reducer/Corrector f/6.3	112
Piggyback Counterpoise f/C5	59.95	T-Adapter	CALL

ACCESSORIES

AC Adapter	18.95	Car Battery Adapter	19.95
Case f/C5 & C8 (Most Models)	174	Lens Shades	CALL
Counterweight Bar Assembly 8"	89.95	11"	94.95
DEC Motor f/C5+, Celestar 8, Ultima 9 1/4/11			CALL
Flashlight Red Astro Lite	9.95	Focus Motor	114.95
Flashlight LED	18.95	Motor Drives	CALL
Focus Micrometer, Digital	109.95	Solar Filters	CALL
Hand Controller f/C+, Celestar 8			49.95

FINDERSCOPES

5x24	23.50	7x50 Polaris	104.95
6x30	39.95	6x30 LER	42.95

FILTERS

4 Piece Filter Sets	49.95	Moon Filter	19.95	Skylight Filter	44.95
LPR Filter Model B f/Back Threads of SC's					84.95
Polarizing Filter Set 1.25"	42.95			LPR Filter Model A 1.25"	59.95

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Barlow 2x 1.25"	44.95	Barlow 2x .96"	19.95
Barlow 2x 1.25 Ultima	CALL	Barlow 2x .96" Dlx	43.95
Diagonal, Erect Image 45°	39.95	Diagonal, Prism Star	39.95
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Plossl 32, 40mm	57.95	Tele-Extender Dlx	48.95
Plossl 6.3, 7.5, 10, 12.5, 17, 20, 26mm			44
Ultima 1.25" 35, 40mm	104.95	Ultima 1.25" 18, 24, 30mm	84.95
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LV SERIES 1.25"

2.5mm	127	6mm	112	12mm	115	20mm	125
4mm	117	9mm	109	15mm	115	25mm	125
5mm	109	10mm	109	8-24mm Zoom			169

RG-240 by L-5 Systems

L-5 Systems announces the start of production of their new 24" telescope, the RG-240. It is a quantum leap ahead of the older JC-524. The design of the split-ring mount and mirror cell has not changed with the exception of heavy-duty stepper motors, planetary gear heads, and a 16.5" spring-loaded worm-and-dec. gear. The truss system and upper portion has been totally re-engineered with two separate focusers on either side of the optical tube. The secondary mirror assembly rotates 180 degrees to accommodate this system.

$25,000

(Shipping & Crating Additional)

TeleVue

"Tops In The Field"

Pronto™

w/1.25", 45° Erecting Prism & 20mm Plossl	$925.00
w/1.25" Mirror Diagonal & 20mm Plossl	$945.00
w/2" Mirror Diagonal & 20mm Plossl	$1085.00

Ranger

70mm ED SCOPE

Available in Ivory, Green or Brass

MANY PACKAGES AVAILABLE!

101 (Green or Ivory)	**$2760.00**
TV-85 (Green or Ivory)	**$1995.00**

EYEPIECES & BARLOWS

ZOOM EYEPICE 8mm-24mm	$210.00

PLOSSL (50°)		**NAGLER (82°)**		**PANOPTIC (68°)**	
8mm 1.25"	82.00	4.8mm 1.25"	175.00	15mm 1.25"	210.00
11mm 1.25"	82.00	7mm 1.25"	220.00	19mm 1.25"	240.00
15mm 1.25"	82.00	9mm 2"/1.25"	240.00	22mm 2"/1.25"	280.00
20mm 1.25"	95.00	***NEW!* RADIAN (60°)**		27mm 2"	330.00
25mm 1.25"	95.00	3mm 1.25"	228.00	35mm 2"	365.00
32mm 1.25"	110.00	4mm 1.25"	228.00	Barlow Interface	90.00
40mm 1.25"	110.00	5mm 1.25	228.00	**BARLOWS**	
55mm 2"/1.25"	230.00	6mm 1.25"	228.00	2x 1.25"	105.00
NAGLER Type 2 (82°)		8mm 1.25"	228.00	3x 1.25"	105.00
12mm 2"/1.25"	285.00	10mm 1.25"	228.00	2x Big 2"	168.00
16mm 2"/1.25"	310.00	12mm 1.25"	228.00	2.5x Powermate	168.00
20mm 2"	395.00	14mm 1.25"	228.00	5x Powermate	168.00

MOUNTS

TELE-POD MOUNT Complete 7 lb mounting system. *Ideal for traveling!*	$310.00
Ash Panoramic Mount	$390.00
Ash Gibraltar Mount	$530.00
Ash Gibraltar & Sky Tour	$1320.00

ACCESSORIES

RICH FIELD KIT Includes: 55mm Plossl, 2" Star Diagonal, SCT to 2" E.P. Adptr & 2" to 1.25" E.P. Adptr	$410.00
RICH FIELD PREMIUM KIT w/Premium 2" Star Diag.	$480.00
Bino Vue Binocular Viewer	$1030.00
Paracorr Photo/Visual 2" Coma Corrector	$235.00
***NEW!** Premium 2" Star Diagonal Mirror*	$255.00
2" Star Diagonal Mirror	$190.00
1.25" Star Diagonal Mirror	$75.00
1.25" Erecting Prism 45°	$60.00
Basic Qwik Point	$18.00
Starbeam Projection Finder	$180.00
Camera Adapter 1.25" & 2"	$36.00
Piggy-Cam Camera Adapter	$42.00

CELESTRON MONTHLY SPECIALS

PixCel CCD CAMERA	**$895.00**
GP-C8 Mount w/Wood Pod (Demo) #91514-GP	**CALL**
FASTAR 8 2032mm (8"), f/10	**$2,089.00**
Skyscope 114 (Demo)	**CALL**
GPC-102 ED 102mm (4"), 920mm f/9	**$1,999.95**
500mm Mirror Lens #81005	**$239.95**

CELESTRON MONTHLY SPECIALS

C90 MULTICOATED OUTFIT

WITH FREE T-MOUNT!

#81011

$349.95

14 days to clear. All orders are subject to verification & acceptance. Shipping, handling & insurance are additional,please call/write for exact details. 14-day money-back guarantee (less shipping) provided merchandise is returned in new condition, unused as received with papers & packaging intact. We gladly accept and reply to written or faxed inquiries. Ad prices available while supplies last. This ad supersedes all previous ads. Focus camera is not responsible for typographical errors. Hours: Mon.-Thurs. 9-7, Fri. 9-2, Sun. 10-6.

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6"f/8 Equatorial Starfinder ($79 P&S)	$649
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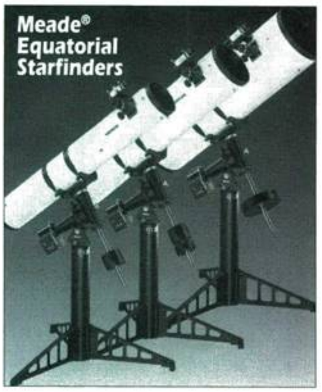
10"f/4.5 Dobsonian Starfinder ($85P&S)	$599
10"f/4.5 Equatorial Starfinder ($99 P&S)	$879
12.5"f/4.8 Dobsonian Starfinder ($95P&S)	$895
16"f/4.5 Dobsonian Starfinder (frt. COD)	$1195
16"f/4.5 Equatorial Starfinder (frt. COD)	$2695

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing and shipping charge to the price. Slightly lower P&S for payment by check. Lumicon showroom prices are $50 to $100 higher.

See the Meade ad in this magazine for full descriptions. Starfinders are complete telescope systems with motor drive and finderscope (Equatorial only) and 25mm (48x) eyepiece. New DC motor runs on four AA batteries.



ACCESSORIES

Magellan computer, specify Dob or Equatorial ($15 P&S) $285; **Lumicon 1¼" UHC or O-III** Filter $99.50. **Vinyl covers** to keep dust free (2 req.) for **6" - $10**; for **8" - $15**; for **10" - $20**; for **16" -$35**.

Meade SCT & Maks 3.5"-16"

NEW! 3.5 f/14 ETX Maksutov ($20)	$595
ETX, showroom price (no long wait)	$615
8"LX10 w/wedge, hand controller ($65)	$995
Field Tripod for 8" LX10 ($20 P&S)	$195
8" LX50 w/wedge ($115 P&S)	$1395
Adj. tripod for 8-10" SCT ($30 P&S)	$295
8" LX200 w/computer ($65 P&S)	$2795
Wedge for photographing w/8" LX200	$139
7" LX50 f/15 Maksutov w/wedge ($125 P&S)	$1795
10" LX50 f/10 w/wedge, dec. motor, hand controller ($155 P&S)	$1695
10" LX 200 w/ computer ($155 P&S)	$3195
12" LX 200 (f/10 only) ($215 P&S)	$4495
SuperWedge for photo. w/10", 12" LX200	$395
16" LX200 f/10 w/tripod ($385 P&S)	$14,950

LX50 – includes dec. motor, hand controller.
LX 200 - full computer control w/64k mem.
Tripod: Extra for LX 50; included for LX200

Note: Wedge is not needed for visual observing with the LX 200. Select f/10 or f/6.3 (no extra charge) for LX 200.

PHOTOGRAPHY ACCESSORIES

Cassegrain Easy-Guider 4"-8" f/6 or f/10	$249
Giant Easy-Guider for 10"/12" f/4-f/10	$395

Dew Shields		
	8" $119	10" $129
	12" ... $189	16" $289

Solar Prominence Filters

See the solar prominences with these spectacular products.

Prices start at **$595.⁰⁰**

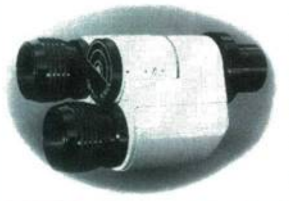
EYEPIECES

Pentax 65° XL

Amazing performance! All have 20mm eye relief, adjustable helical eye guard, super multi-coatings, E.D. Glass

5.2mmF.L., 65°Apparent Field 1¼"	$279
7mm F.L., 65° Apparent Field 1¼"	$279
10.5mmF.L., 65°Apparent Field 1¼"	$269
14mm F.L., 65° Apparent Field 1¼"	$269
21mmF.L., 65°Apparent Field 1¼"	$269
28mm F.L., 55° Apparent Field 1¼"	$259
40mmF.L., 65°Apparent Field 2"	$299

New LUMICON® binocular viewer



The new LUMICON Binocular viewer is judged to be equal or superior to even more expensive binoviewers. Custom made for Lumicon , these exquisite German-made units have the highest image transmission (91%) Threaded for filters. Both planetary and deep-sky viewers will be impressed. **$749.⁰⁰**

3X apochromatic relay lens for Newtonians **85.⁰⁰**

Takahashi

Telescopes and accessories. 10% off!
Call for details

Adjustable piggyback mount

LUMICON's piggyback mount is ideal for telescopes of 6-16" aperture. It permits both vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER, large telephoto lenses and small telescopes up to about 5 lbs.

Lumicon Adj.Piggyback Mount	$59.50

Specify telescope size: 6", 8", 10", 11", 14", 16".

H-ALPHA pass filter

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) filter.

Specify Lens Size	**H-Alpha**	**DS**
46,48,49mm	$59.00	$199.50
52,55,58,62mm	$69.00	$199.50
67,72,77mm	$79.00	$399.50
82mm (77mm+adapter)	$89.00	$415.00

Hypered 2415 film, 36 exp	$11.95

Lots of Adapters

2" adapter for C-8 Meade 2080, etc.	$29.50
2" adapter for C-80, C-102 refractor	$39.50
2" adapter for C-70, C-80F, C-102F fluorite	$39.50
2" adapter for C-6, Comet Catcher, Meade 395	$30.00

Extension Tubes

1" long 1¼" OD thread-in extension	$12.00
2½" long extension (holds 1¼" filters)	$19.50
4½" long extension for 1¼" eyepieces	$29.00
3" long extension for 2" eyepieces*	$29.00
2" long extension for 2" eyepieces*	$29.00

Viewing Adapters

2"\1¼" reducing bushing, thread 48mm*	$25.00
2" T-thread adapter, threaded 48mm*	$25.00
T-thread 1¼" adapter	$25.00
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	$59.50
Low profile star diagonal eyepiece holder	$16.00
Meade 2" diagonal /Giant Easy-Guider	$39.50

**threaded to hold 48mm filters*

Low Profile Focusers

Select your desired base plate shape: Coulter Odyssey (thread on installation), Flat 7",9½"OD, 12½"OD, 16"OD, 21"OD.

Lumicon 1¼" Helical Focuser	$69.50
Lumicon 2" Helical Focuser (1½" high)	$85.00
2" Astro systems focuser (only 2"high)	$149.00
2"/1¼" adapter w/48mm filter threads	$25.00
2" LUMICON Easy-Guider™	$189.50

LED flashlight $14.⁹⁵

This red LED flashlight preserves night vision. 2 AA cells (incl.) will last 60 to 100 hours.

Lumilite™ red LED flashlight	$14.95
Starlite™ adjustible red LED flashlight	$24.95
Skylite™ adjustible white/red LED	$29.95
Kuikfinder 1X reflex finder	$39.95

Large UV/Dust Seal

Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. A/R Coated.

Deep-Sky filter/dust seal for C-8, 2080	$199.50
UV/Dust Seal for Celestron C-8	$39.00
UV/Dust Seal for Meade 4"-8"	$39.00
UV/Dust Seal (lg.) for Meade 10"-12"	$89.50
UV/Dust Seal for Celestron 11"-14"	$89.50

New Lower Prices

Tele-Vue

4X Powermate for 2" eyepieces	$265
5X Powermate boosts magnification 5x	$168
Ranger 70mm f6.8 apchromat w/45° diag.	$695
Pronto 70mm f6.8 w/45° erecting prism	$925
Tele-Vue 85, 85mm f/7 APO telescope	$1995
Bino-Vue binocular w/2x correc.	$1030
Gibraltar mount with ash wood tripod	$530
8,11,15mm Plossl . $82 — **20,25mm**	$95
32mm Plossl, widest true field in 1¼"	$110
55mm Plossl, widest possible field	$230
2.0x or 3.0x Tele Vue Barlow Lens	$105
2" Giant Barlow – 2x	$168
4.8mm Nagler 82° field, 1¼" eyepiece	$175
7mm Nagler, 1¼" eyepiece, 82° field	$220
9mm Nagler, 82° field 1¼" or 2"	$240
12mm Nagler Type 4, 82° 1¼" or 2"	$340
16mm Nagler Type II, 82° 2" only	$310
2" Paracorr visual coma corrector	$235
3,4,6,8,10,14mm Radian, 60° field	$228
15mm Panoptic 1¼", 68° field	$210
19mm Panoptic 1¼", 68° field	$240
22mm Panoptic 1¼"/2", 68° field	$280
27mm Panoptic 2", 68° field	$330
35mm Panoptic 2", 68° field	$365

Note: TeleVue warranty may not be valid outside USA

Dust Covers

Protect your valuable telescope optics eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10% for 2 or more sets.

1¼" O.D. plug, seals focuser			4/$2
2" O.D. plug	2/$2	3½" O.D. plug	$1.50
1¼", 1⅜"	3/$2	7½"	$10
1½"	2/$2	9½", 10.4"*	$15
2"	2/$2	12½",12⅞"*	$20
2⅛"	2/$2	15", 15.6", 16"*	$28
5½"	$6	19" (DS-16)	$35
*Fits Odyssey		21" (Odyssey-II)	$35

2" Deluxe Barlow

LUMICON 1.8x Multiplier Lens	$259.00

LUMICON

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Lumicon 50mm & 80mm SUPER FINDER

Visual astronomers prefer the **LUMICON 80mm Super-Finder™,** since hundreds of deep-sky objects, including most Messier objects, are visible directly. Super-Finders™ also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat: or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1 1/4" **50mm** finderscope or 45° version	$69.50
1 1/4" **straight-thru 80mm** superfinder	$199.50
1 1/4" **right angle 80mm** superfinder	$209.50
1 1/4" **right angle** version, w/ star diagonal	$249.50
25mm cross-hair 1 1/4" eyepiece (12X)	$59.00
Large mounting rings for 80mm finder	$55.00
1 1/4" **star diagonal**	$49.00
Mounting brackets, 50mm finder	$39.50
1 1/4" **45°** diagonal /correct left-right views	$49.00
1 1/4" **90°** Amici diagonal, correct l/r views	$59.50

Celestron Telescopes

Celestar-8	$1199
Ultima 2000 8" (in stock)	$2799

Call for prices on all other model Celestron telescopes., including Schmidt-Cassegrains, Dobsonians and refractors.

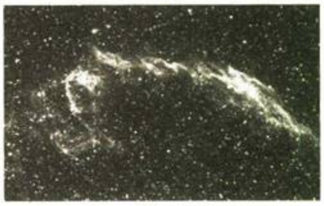
Enhanced Mirrors Boost Telescope Performance

1.32"	$39.50
1.83"	$49.50

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1 1/4" (1.32" mirror)	$99.50
2" (1.83" mirror) (see photo above)	$189.50

LUMICON FILTERS - BEST IN THE WORLD



AMAZING O-III FILTER™

"The LUMICON O-III proved to be our favorite . . .it gave the greatest contrast gain." *ASTRONOMY, February 1991*

Greatly Enhanced Detail

"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in more than two dozen objects I viewed." *SKY & TELESCOPE, July 1995*

Better than a Dark Sky Site?

"From my light-polluted backyard, the view was better with my O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." *SKY & TELESCOPE, July 1995*

See The Horsehead!

"LUMICON's H-Beta Filter will show subtle features in emission nebulae that others fail to reveal. It can't be beat for the elusive Horsehead and California Nebulae." *SKY & TELESCOPE, July 1995*

Deep-Sky Filter™
BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for both color and black and white photography.

Best Wide-Band Filter!

"Based on our tests, we'd recommend a LUMICON Deep-Sky and Oxygen III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for reflection nebulae." *ASTRONOMY, February 1991*

LUMICON Multiple Filter Selector, holds 5 1/4" filters	$129; $99 if ordered w/filter
1 1/4" **LUMICON DEEP SKY Filter** threads into most 1 1/4" eyepieces	$99.50
48mm LUMICON DEEP-SKY Filter threads into most 2" eyepieces. Also fits EASY-GUIDERS	$199.50
2" LUMICON DEEP-SKY Filter threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$199.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	$399.50
2" Rear Cell Filter, fits SCT's............Deep-sky, $199.50 UHC,O-III, H-Beta	$199.50
1 1/4" **LUMICON UHC Filter** threads into most 1 1/4" eyepieces	$99.50
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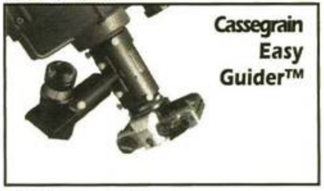

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Libra and Serpens Caput

The scales of justice and the serpent's head provide a nice balance of distant galaxies and globular clusters.

by Tom Polakis

Artwork at left originally published in *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

WITH THE BALMIER days — and nights — of late spring upon us, it's time to grab a telescope and get reacquainted with observing in comfort. By late evening, the galaxy fields of Virgo lie high in the southwest while the star clouds in Sagittarius and Scorpius begin to emerge along the eastern horizon. Sandwiched between these regions, which inspire such fervor among deep-sky observers, are two more-tranquil constellations: Libra and Serpens Caput. Yet these star patterns offer splendid observing targets that reflect their location, with a wide assortment of galaxies on the constellations' western sides and fairly typical Milky Way objects to the east.

Libra the Scales, or Balance, apparently first acquired this name in ancient Babylon, some 4,000 years ago. At that time, the sun resided in Libra at the autumnal equinox, when day and night have equal lengths and are in balance. (Thanks to precession, the slow wobble of Earth's axis under the influence of the sun's and moon's gravity, the autumnal equinox now lies in Virgo.) Oddly enough, the names of Libra's two brightest stars hearken back to a different era. Zubenelgenubi and Zubeneschamali translate from Arabic as the "Southern Claw" and "Northern Claw" because they were perceived to be the pincers of the neighboring constellation Scorpius the Scorpion. These two 3rd-magnitude stars join with several fainter stars to their south and east to create the ill-defined form of the constellation.

Serpens the Serpent represents a snake held by the serpent-bearer, Ophiuchus. Unique among the constellations, Serpens consists of two separate parts: Serpens Caput and Serpens Cauda, which represent the head and tail of the snake, respectively. A meandering string of 3rd- and 4th-magnitude stars produce the shape of Serpens Caput, which is no easier to trace than Libra. Unukalhai, the brightest of these stars at magnitude 2.7, forms the neck of the snake. The serpent's head comprises a small equilateral triangle of 4th-magnitude stars at the northern end of the constellation.

The first stop on our tour of these constellations is a naked-eye sight, the fine double star **Alpha (α) Librae** (Zubenelgenubi). Nearly 4' separate the two stars, so average eyes should be able to split the pair. However, you'll need to observe from a reasonably dark site to glimpse the 5th-magnitude companion star to the northwest of the 3rd-magnitude primary. (Binoculars certainly make the task much easier.) Both lie 77 light-years from Earth and radiate more energy than the sun, with the brighter component putting out 30 times the sun's light.

You'll need a telescope to view our tour's next stop: the galaxy **NGC 5728.** Located 2.4° west-southwest of Zubenelgenubi, this barred spiral has an exceptionally bright nucleus that also classifies it as a Seyfert galaxy. A type of active galaxy, Seyferts emit prodigious amounts of visible and infrared radiation from tiny regions in their core. Through a 10-inch telescope, NGC 5728 appears as a faint halo measuring 3' by 1' with a much brighter stellar nucleus. A foreground star located just 20" northeast of the core gives the impression of a double nucleus. You may see a second star at the southwestern end of the galaxy's halo, which lies roughly 140 million light-years beyond these apparent intruders from our own Milky Way.

Heading 8° southeast of Zubenelgenubi brings us to the showpiece of Libra, the globular cluster **NGC 5897**. At a distance of 40,000 light-years, the cluster's brightest stars shine dimly at 13th magnitude. Still, enough stars group together here that their combined glow raises the cluster's overall magnitude to 8.6, making it fairly easy to spot in 11x80 binoculars. The most striking aspect of NGC 5897 is how loosely its stars concentrate toward the center. Through an 8-inch telescope at a dark site, only the brightest dozen or so stars can be seen against a faint, cometlike glow. A 13-inch scope brings the star count up to 50. In a 20 inch at 200x, stars scatter widely across the cluster's center with little apparent concentration.

The small planetary nebula **Merrill 2–1** lies only 3° south-southeast of NGC 5897. Discovered by Paul Merrill in 1942, this diminutive object nevertheless has a bright disk that snaps into view when observed with a nebula filter. An 11th-magnitude star fortuitously located just 1' to the west offers an easy way to judge the planetary's brightness. A 10-inch or larger telescope at low magnification may concentrate sufficient light into a small enough area for you to detect a slight bluish color. At 400x in a similarly large scope, the disk appears at its full 7" size and sports a hazy edge. Located some 15,000 light-years from Earth, this shell actually spans half a light-year.

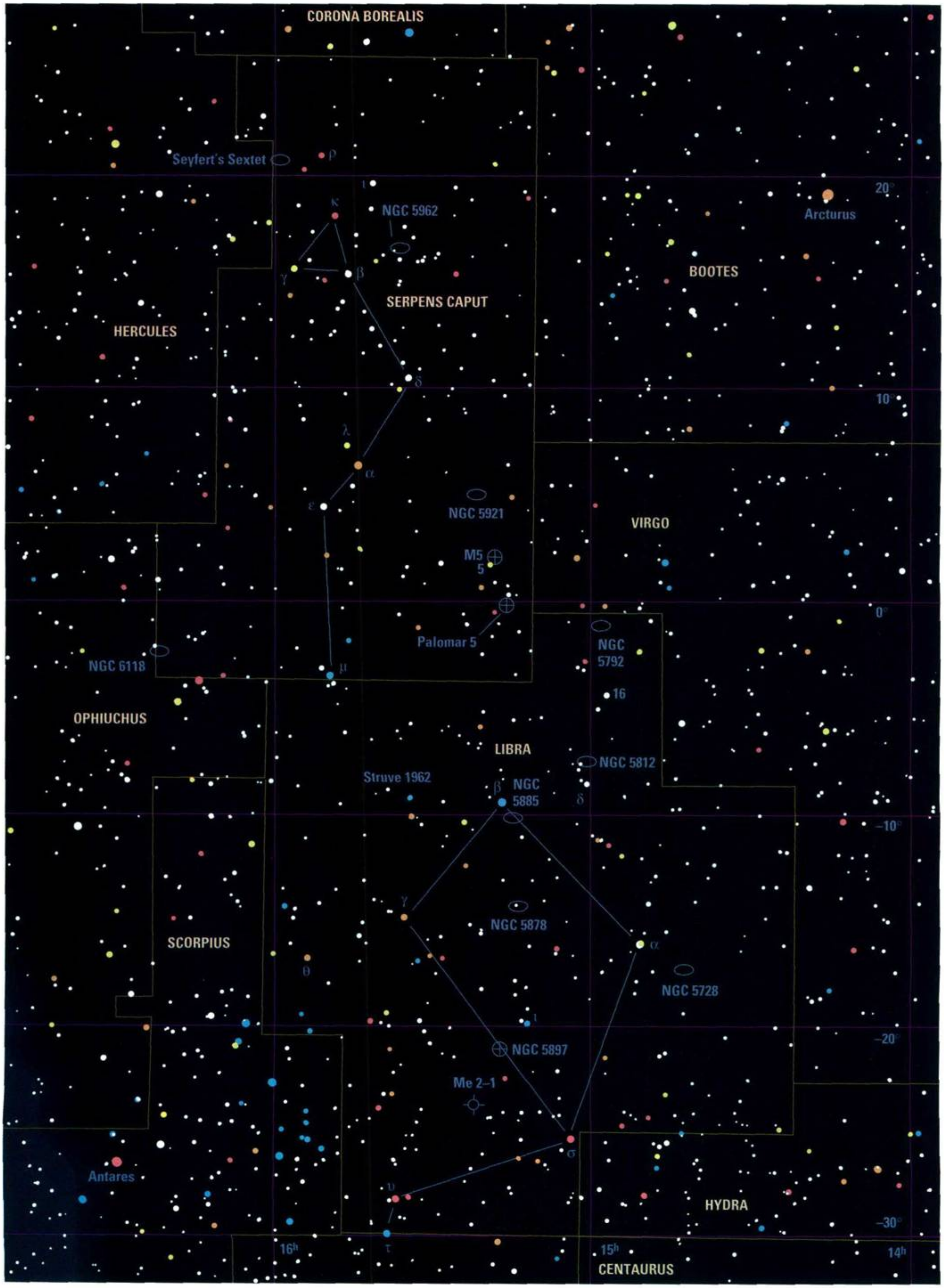
Far beyond the confines of our own galaxy lies **NGC 5878**. At a distance of 100 million light-years, this spiral galaxy doesn't offer a lot of detail in most backyard telescopes. Look for a spindle about three times as long as it is wide located approximately halfway between the bright stars Alpha and Gamma (γ) Librae. The galaxy inclines 29° to our line of sight and possesses a bright core highlighted by an even brighter nucleus that appears stellar. In 1988 a supernova shone faintly in this distant island universe.

Less than a degree southwest of Beta (β) Librae, at magnitude 2.6 the brightest star in the constellation, lies the barred spiral **NGC 5885**. A 10-inch telescope shows this galaxy as a nearly uniform, faint haze. Unfortunately, even a large scope fails to show the elusive spiral structure that appears only on deep photographs. A 10th-magnitude foreground star blazes just beyond the northeastern edge of the galaxy's halo.

The pretty double star **Σ1962** (Struve 1962) resides 5° east of Beta. A

M5

Jason Ware


CORONA BOREALIS
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HERCULES
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Palomar 5
NGC 5792
NGC 6118
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OPHIUCHUS
LIBRA
NGC 5812
Struve 1962
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NGC 5885
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NGC 5878
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SCORPIUS
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NGC 5897
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Antares
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HYDRA
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16h
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14h
CENTAURUS

small refractor at 30x will split this pair of nearly identical stars, which are separated by a healthy 12". Each appears yellow-white and shines around magnitude 6.5. Added together, the pair glows at magnitude 5.8 and can be seen with the naked eye from a dark site. Although a little bit hotter and brighter than the sun, these stars give a good idea of how our sun would appear from a distance of 80 light-years.

Another interesting naked-eye target lies some 4° west-northwest of Beta Librae. Every 2.33 days, the 4.9-magnitude star **Delta (δ) Librae** dims by a full magnitude. An eclipsing binary system, Delta consists of two stars in orbit around each other. Whenever the cooler, fainter star passes in front of its hotter, brighter companion, the system experiences a 60 percent drop in brightness. The fall to minimum takes about six hours, with an equal amount of time required to regain its normal brightness. A much smaller drop in brightness, of just 0.1 magnitude, occurs when the brighter star eclipses the fainter. Use 16 Librae, located 4° to the north, to chart Delta's changing brightness. Three times out of four, Delta will appear nearly as bright as this star, but, during eclipses, it glows conspicuously fainter and approaches the brightness of the 6th-magnitude star that lies 0.8° southeast of 16 Lib.

A quick pan 1° due north of Delta picks up the bright elliptical galaxy **NGC 5812**. In an 8-inch instrument, it looks perfectly round and spans 1'. Some observers liken its appearance to a planetary nebula. Large-aperture telescopes bring out a much fainter outer halo, some 2' across, and show the fainter galaxy IC 1084 about 5' to the east. Both galaxies reside roughly 100 million light-years from Earth, placing them well beyond the Virgo Cluster in Libra's western neighbor.

The northernmost reaches of Libra hold what is arguably the finest galaxy in the constellation. The barred spiral **NGC 5792** lies nearly edge-on to our line of sight, so it appears quite elongated in backyard scopes. A 13 inch shows a stellar nucleus with faint wings extending a total of nearly 5'. You won't actually see spiral structure, but the spiral arms do produce mottling near the core that's visible in larger scopes. Unfortunately, a 10th-magnitude star on the galaxy's northwestern edge hinders the view of faint detail.

An easy sweep 6° to the northeast of NGC 5792 brings us to Serpens Caput and the brightest globular cluster in the northern half of the sky. At magnitude 5.7, **M5** (NGC 5904) can be seen with the naked eye under moderately dark skies and is a spectacular sight in any telescope. Be sure not to confuse it with the 5th-magnitude star 5 Serpentis, which lies less than half a degree to the southeast. Although the globular currently dwells 21,000 light-years from the galaxy's center, studies of its proper motion show that it travels in a huge elliptical orbit that takes it out as far as ten times this distance every 500 million years. Right now it lies 26,000 light-years from the sun.

Because M5 contains a number of stars brighter than 13th magnitude, a 4-inch telescope resolves it well. At 150x, expect to see a granular object with dozens of stars visible across a moderately compressed core. The faintest members visible in a 4 inch shine at least one hundred times more brightly than the sun. With 10 inches of aperture, M5 reveals more than a hundred stars crammed into an area 10' across. The cluster's edge seems to break up into streamers that radiate into the surrounding empty fields.

Deep-Sky Objects in Libra and Serpens Caput

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep./Per.	Type	Notes
NGC 5728	14h42.4m	–17°15'	11.5	3.7' by 2.6'	Gal	SB(rs)a
Alpha Librae	14h50.9m	–16°02'	2.8/5.2	231"	Dbl	Zubenelgenubi
NGC 5792	14h58.4m	–1°05'	11.2	7.3' by 1.9'	Gal	SAB(rs)b
NGC 5812	15h01.0m	–7°27'	11.2	2.3' by 1.9'	Gal	E1
Delta Librae	15h01.0m	–8°31'	4.9–5.9	2.327 days	Var	Eclipsing binary
NGC 5878	15h13.8m	–14°16'	11.5	3.0' by 1.4'	Gal	SAB(s)bc
NGC 5885	15h15.1m	–10°05'	11.8	3.2' by 2.6'	Gal	SB(r)cd
Palomar 5	15h16.1m	–0°07'	11.8	6.9'	GC	
NGC 5897	15h17.4m	–21°01'	8.6	12.6'	GC	
M5 (NGC 5904)	15h18.6m	2°05'	5.7	17.4'	GC	
NGC 5921	15h21.9m	5°04'	10.8	4.9' by 4.2'	Gal	SB(r)bc
Merrill 2-1	15h22.3m	–23°38'	11.6	7"	PN	
NGC 5962	15h36.5m	16°37'	11.3	2.6' by 1.8'	Gal	SA(r)c
Σ 1962	15h38.7m	–8°47'	6.5/6.6	11.9"	Dbl	
Seyfert's Sextet	15h59.2m	20°45'	14	2' by 1'	Gals	NGCs 6027 & 6027A-E
NGC 6118	16h21.8m	–2°17'	11.7	4.6' by 1.9'	Gal	SA(s)c

Object: Designation in Messier, NGC, or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep/Per:** Size in arcminutes or arcseconds, separation in arcseconds, or period in days. **Notes:** Hubble type for galaxies.

The Scale

"Poetic Justice, with her lifted scale,
Where in nice balance truth with gold she weighs,
And solid pudding against empty praise."
The Dunciad
— Alexander Pope (1688–1744)

Resting at Virgo the Maiden's feet and just above Scorpius the Scorpion lies Libra, the seventh constellation of the zodiac and the only one of the twelve to represent a non-living being. The Greeks called this region of sky Chelae, which means claws. Libra's two brightest stars, Zubenelgenubi (Alpha [α] Librae) and Zubeneschamali (Beta [β] Librae), once marked the southern and northern claws of the giant scorpion.

Today the constellation of the claws is better known as the Scale, and Libra maintains closer kinship with Virgo, who represents the celestial version of Dike, or Astraea, the goddess of justice. Where did this association originate? From approximately 2400 to 700 B.C., the sun lay among the stars of Libra at the autumnal equinox. On this day of "equal night," the sun rises due east and sets due west and the hours of day and night are in balance. Many historians believe this symmetry led the Sumerians to refer to Libra's region of sky as Zibbaanna, the balance of heaven.

Zubenelgenubi and Zubeneschamali were once the symbol of the equinox, yet they may have had very different brightnesses. And therein lies an astronomical mystery and controversy. In the third century B.C., the Greek astronomer Eratosthenes labeled Zubeneschamali the brightest of all stars in Scorpius and Libra, implying that it outshone even Antares. Some 400 years later, the great second-century astronomer, Ptolemy, assigned Zubeneschamali and Antares the same brightness.

Today, of course, Zubenelgenubi and Zubeneschamali shine just about equally while Antares glows nearly five times brighter. As a red supergiant star, Antares varies slightly in luminosity, and it's not impossible for it to have grown at least somewhat brighter over a couple thousand years. But Zubeneschamali seems a normal, stable star that shouldn't have dimmed noticeably in historic times. Unfortunately, this mystery will likely endure, with its solution lost in the mists of time. — *Andrea Gianopoulos*

Large apertures really shine on globular clusters, and M5 offers a stunning demonstration of this effect. A 13-inch telescope will show more than 500 stars down to 16th magnitude in the central 12' — truly an eye-popping spectacle. In larger scopes, the cluster sprawls to 15' in diameter with too many stars to count. Although the central 7' provides an incredible density of stars, it appears fully resolved against a bright background of still more stars. Outside this core the stars appear fainter and the edge becomes difficult to define.

You can spy a globular cluster on the other end of the brightness scale just a short star-hop south of M5. **Palomar 5**, one of 15 globulars George Abell discovered on the Palomar Observatory Sky Survey in 1955, boasts no star brighter than 15th magnitude. Simply seeing a faint glow in the position of Palomar 5 should be considered an observing accomplishment, let alone resolving any stars. Through a 20-inch telescope on a dark night, I saw it as an extremely faint, uniform glow measuring only 3' across. Other observers have spotted the faint cluster with apertures as small as 13 inches. Palomar 5 completes one orbit about the galaxy's center every 400 million years and currently resides 55,000 light-years from the center and 70,000 light-years from the sun.

M5 also serves as a good starting point for finding the barred spiral galaxy **NGC 5921**, which lies just 3° to the north of the globular cluster. In a 10-inch telescope, it spans 2' by 1' and shows a bright center. The galaxy's bar can be seen with some difficulty, as can a faint oval ring that hints at spiral structure. NGC 5921 lies 75 million light-years from Earth, far beyond the 12th-magnitude foreground star that appears on the southwestern edge of the galaxy's halo. UGC 9830, a satellite galaxy to NGC 5921, lies 36' to the south-southeast.

Our next stop takes us to the far eastern side of Serpens Caput, where it borders with Ophiuchus. The faint

NGC 6118

Martin Germano

NGC 5921

Harvey Freed

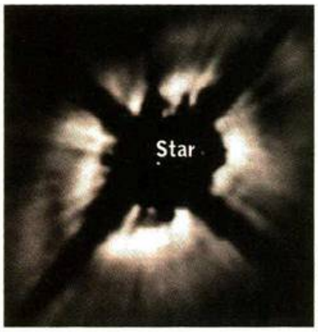
NGC 5792

Kim Zussman

A New Planet in Libra?

Planets circling other stars have become all the rage in the past few years. Most betray their presence by inducing subtle swings in their parent star's motion, which show up in the star's spectrum. Now, for the first time, astronomers have inferred a planet from the gap it creates in the dusty disk surrounding a star.

The young, 7th-magnitude star named HD 141569 lies 320 light-years away in Libra, just ½° south of Mu (μ) Serpentis. It glows brightly in the infrared because the disk of dust absorbs the star's ultraviolet and visible light and reradiates it in the infrared. Although this disk was discovered in 1986 by the Infrared Astronomical Satellite, it took the superior optics of the Space Telescope to show the large gap.



NASA/STScI

Using the Near Infrared Camera and Multi-Object Spectrometer, Alycia Weinberger of UCLA and her colleagues blocked the light of the parent star so they could zero in on the disk. Surprisingly, the disk appears in two parts — a bright inner region and a fainter outer region separated by a dark band. Superficially, at least, the gap resembles the Cassini Division in Saturn's rings.

"The most obvious way to form a gap in a disk is with a planet," says Weinberger. "The planet could either be sweeping up the dust and rocks from the disk as it travels in its orbit around the star, or the gravity of the planet could knock the dust out of one part of the disk."

The planet interpretation does raise a question, however. The disk is huge, stretching some 400 astronomical units (one AU is the average distance of Earth from the sun, or approximately 93 million miles) from HD 141569 with the gap lying 250 AU out.

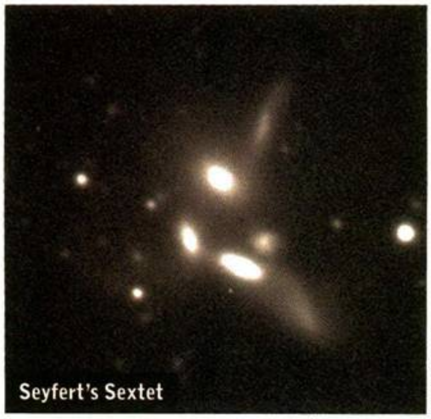
Theorists haven't yet figured how a decent-sized planet could form so far out — much farther than Pluto's distance from the sun. There shouldn't be much raw material out there for making planets, and even if there were, collisions would likely take place too infrequently to build a planet. UCLA collaborator Eric Becklin admits that there could be material in the gap with a different composition that simply reflects less light. Still, a planet seems to be the simplest explanation and currently makes the most sense. — *Richard Talcott*

spiral galaxy **NGC 6118** is notorious as one of the most challenging members of the Herschel 400 list of deep-sky objects. A 10-inch scope shows it as a very faint, uniform haze measuring 4' by 2'. A large telescope at a good observing site reveals a tiny, brighter core and weak hints of spiral structure on the galaxy's eastern end. Three 14th-magnitude stars are embedded in the glow.

The spiral galaxy **NGC 5962** lies in northern Serpens Caput, just west of the trio of 4th-magnitude stars that forms the serpent's head. This galaxy exhibits "flocculent" spiral structure, meaning its arms appear to be broken up into many small pieces in contrast to the "grand-design" spirals with smooth arms. In the eyepiece, NGC 5962 appears 2' by 1' across with a broad central concentration. A sharp, bright nucleus some 15" in diameter lies at its very center.

The final stop on our tour brings us to an intriguing group of six galaxies jammed into an area of sky just 2' across. **Seyfert's Sextet** — the 79th entry in a catalog of compact groups of galaxies compiled in 1982 by Paul Hickson — lies 2° east of the 5th-magnitude star Rho (ρ) Serpentis. Like its cousin Stephan's Quintet in Pegasus, it contains one member that doesn't seem to fit.

As the universe expands, it carries the galaxies along with it. This means that the farther away a galaxy is, the faster it recedes from us and the more its light gets shifted toward longer wavelengths, or redshifted. Five members of Seyfert's Sextet recede at a speed that implies a distance of approximately 200 million light-years, but one, the galaxy designated NGC 6027D, moves away from us disturbingly faster — at nearly five times this speed. The debate rages whether this galaxy really lies five times farther away than the other members and just happens to be aligned by chance or whether it is part of the galaxy group possessing an unexplained redshift. Although most astronomers believe this to be a chance alignment, some signs point to membership. For one, the galaxy would have to be quite luminous (although not extraordinarily so) to appear as bright as it does from its distance of 1 billion light-years. Further, it shows subtle hints of interaction with the other galaxies in the sextet.


Seyfert's Sextet
Kim Zussman

To see Seyfert's Sextet requires at least 10 inches of aperture, and the bigger the telescope, the better your chances. Still, at magnifications below 200x, it's easy to mistake this group for a single glowing object. On transparent and steady nights, you'll have the best luck spotting NGC 6027, NGC 6027A, and NGC 6027E. None of the galaxies shows any real structure, however, and at best appear barely non-stellar in any size scope. Detecting all six group members ranks as a major accomplishment and would be a grand way to close out your tour of the serpent's head. ■

Tom Polakis is an aerospace engineer who lives in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

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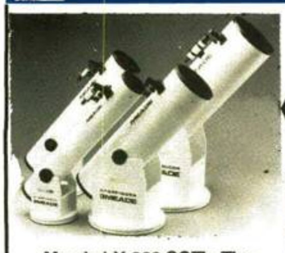

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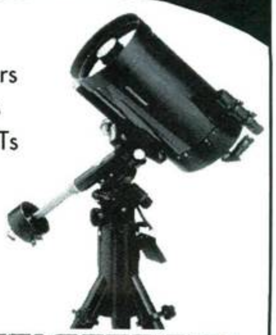

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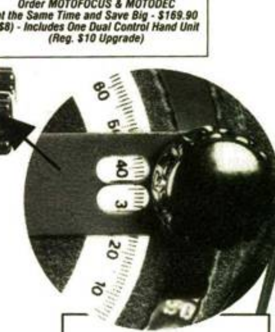

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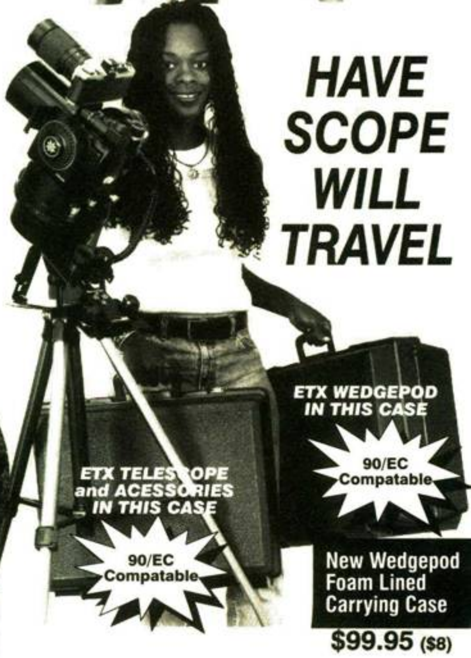

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Is a 6-inch, equatorially mounted reflector costing $600 too much telescope for the beginning skygazer? I pondered this as I test drove the new 6-inch Starsplitter Gem, the midsize model in a new line that includes 4-inch f/8 and 8-inch f/4 versions.

Starsplitter is a relative newcomer in the astronomical marketplace. Established by owner Jim Brunkella in 1992, the company has demonstrated a high standard of excellence in quality and craftsmanship. Dobsonian-mounted reflectors of truly astronomical proportions are the house specialty — the Starsplitter II Ultimate series boasts one model with a colossal 40-inch primary mirror. Only recently has the company teamed such big league scopes with a family of little leaguers — the Gem series.

Starsplitter Gems are designed for the serious beginner. Each model includes a sturdy yet lightweight and expandable aluminum tripod that is braced by a spacious accessory shelf and topped by a heavy-duty German equatorial mount. Clamps, not bolts, secure the tube to the mount. No matter which way the Gem is pointed, an observer can loosen the clamps and rotate the tube to ensure convenient eyepiece position.

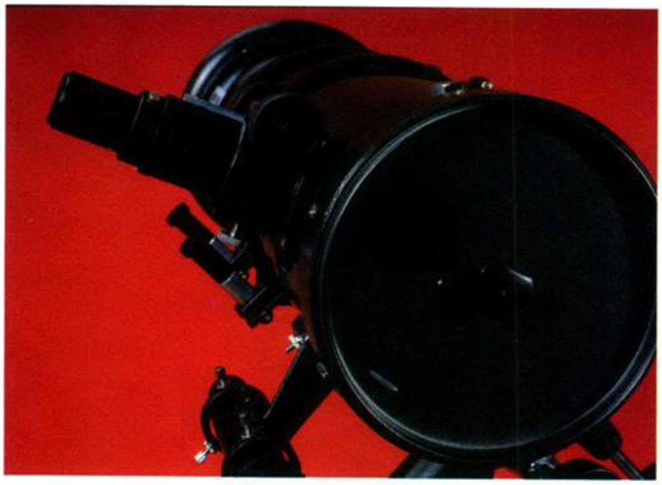
text by Glenn F. Chaple, Jr. / photographs by Jim Forbes

The mount has a number of other features normally associated with more expensive telescopes. These include a polar alignment scope and altitude and azimuth adjustments. An optional motor drive is available for prolonged observing or astrophotography. Some of these features will not be necessary for the beginner but will become useful as he or she becomes more involved with astronomy. The Starsplitter Gem is made to grow with its owner.

The heart of the 6-inch Gem is a standard f/5 Pyrex mirror secured firmly in place by a cushioned cell. Three lockable screws at the base of the tube allow for quick and easy collimation. The secondary rests on an adjustable three-vane support. A smooth-running rack and pinion focuser accepts a wide range of standard 1.25-inch eyepieces. Aiming the Starsplitter Gem is accomplished with a 6x30mm finder supported by a double post bracket and six collimation screws. The entire optical assembly weighs a mere 10 pounds.

Though the Gem requires initial assembly, the accompanying owner's manual simplifies the job. The text is clearly written and easy to follow, even if a few of the illustrations didn't match corresponding parts on the telescope. Still, the straightforward design of the Gem facilitated assembly. The entire task was completed in about an hour, despite frequent pauses to take notes. The only tool needed is a pair of pliers.

Would a true beginner, for which the Gem was designed, fare as well? I asked a local 5th-grade teacher who happens to be a budding skygazer to try her luck. With minor assistance from her teenaged son, she put the Gem together in under an hour. Like me, she found that the manual drawings weren't as helpful as they could be. How about including an inexpensive video that demonstrates assembly and set-up techniques?



Once you know what you're doing, you can assemble and disassemble the Gem in 15 minutes. But why bother? Unclamping the tube assembly breaks the scope down into two parts — three, if you separate the mount and tripod. Each section can be easily transported in and out of the house or to an automobile for the trip to a dark-sky site.

The scope looks good, but looks mean nothing if it's not user friendly. My teacher friend had been experiencing difficulty operating a brand-name equatorial scope that her school owns. For her, the Starsplitter was indeed a gem. Though she stumbled a bit at first, with practice she began enjoying success.

Part of the problem arose from the only serious flaw I found with the Gem I tested. The finderscope was slightly out-of-focus. Nothing in the manual described how to focus the finder, but a few twists here and there solved the problem. Switching eyepieces and focusing the Gem were a snap. The views of Jupiter and Saturn were spellbinding. She loved the "wheels," or right ascension and declination slow motion controls, that made following these cosmic wonders a simple task. Even so, the rolling motions of an equatorial mount took her some time to get used to. First-time users of an equatorial telescope should spend an hour or two practicing their aim and focusing on terrestrial objects during daylight hours. Only after this ground school session will you be ready for the stars.

Initial night-sky forays consisted of a random survey of showpiece objects. The moon was magnificent. Its rugged features were sharply etched. Jupiter and its moons also stood out brightly — a reminder that a 6-inch reflector collects over two times the light of a standard 2.4-inch refractor. A deep space plunge netted the great globular cluster M13 and resolved it into a blaze of tiny stellar specks. The Ring Nebula (M57) showed its classic shape, while the Veil Nebula (NGC 6960 and NGC 6992–5) in Cygnus revealed its characteristic large, faint, semicircular glow. The most important thing discovered during those initial sessions? The Starsplitter Gem is fun to use.

Telescopes that rest on an equatorial mount can be awkward to operate. But not the Gem. Right ascension and declination locks, as well as slow motion controls, are handily located. The mount also proved to be quite steady, even with the tripod legs fully extended. Vibrations caused by a tap on the tube settled down in seconds, and the Gem stayed on target during those critical moments when I switched eyepieces.

Though the 6-inch Gem is designed for the beginning observer, its value to an experienced amateur astronomer became evident during later observing sessions. Using an Amateur Association of Variable Star Observers chart, I tried to determine the faintest star visible in the field around the variable star RX Andromedae. With low power, the Gem brought out a 13.3-magnitude star — not bad for a 6-inch scope. Still, I felt the Gem could do better. Using high power to increase contrast, I rechecked the field. This time, the faint glimmer of a magnitude 13.9 star popped into view. On a better night, I'm sure the Gem could have cracked 14th magnitude. However, the best was yet to come. Spotting the Pleiades above the treetops to my east, I decided to test the field of view on this large target. The entire cluster fit nicely in

Top left: Though a solar filter is still needed, the telescope's cap has the added feature of allowing the observer to stop down the aperture for solar observing. Bottom left: Set-up and take-down are made simple with easy-to-use mounting rings.

6-inch Gem Specifications

Aperture: 6 inches (150mm)
Focal Length: 760mm
Focal Ratio: 5
Tube Length: 28.5 inches
Focuser Size: 1.25 inches
Eyepieces Included
    (1.25 inch): 25mm
    (30x) and 10mm
    (76x) Plössl
Finder: 6x30mm
Secondary: 1.52 inches
Secondary Obstruction:
    (by diameter) 25%
    (by area) 6%
Total Weight: 40 lbs.
Eyepiece Height at Zenith: 3'8" (4'9" when the tripod
    is fully extended)
Retail Price: $599
Delivery: (in stock) 7 to 10 days
    (not in stock) no more than 30 days
Options: R.A. Drive Motor $149 plus $6 S&H
    Dual Axis Drive Motor $229 plus $12 S&H
    Camera Adapter, $24.95 plus $5 S&H
    2x Barlow lens, $29.95 plus $5 S&H

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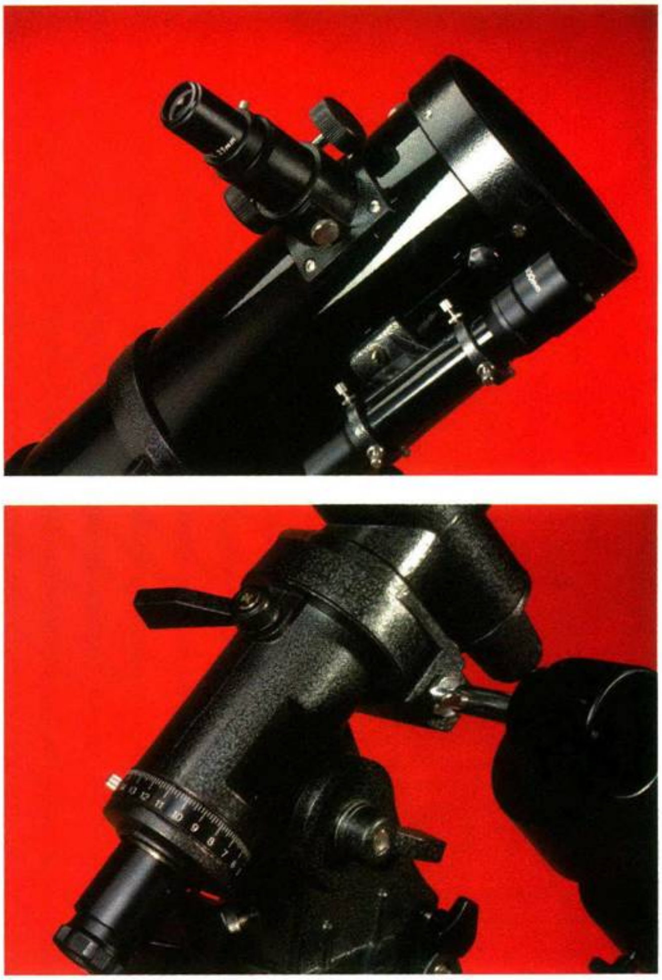

Top: The Gem's 6x30mm finder and 1.25-inch rack and pinion focuser. Bottom: To easily track objects, adjust the Gem to Earth's axis of rotation by using the polar alignment scope.

the 1.5° low-power field. While admiring the view, I noticed a misty patch near one of the Pleiades. Eyepiece fog, I assumed, because in all my years of skygazing I had never before seen the elusive nebulosity associated with this cluster. Careful scrutiny of the field, followed by an indoor check of a sky guide, confirmed that I had indeed seen the Merope Nebula — for me, a milestone. The 6-inch Gem can "go deep!"

A telescope is great for sightseeing, but occasionally it may be called upon to do serious work. As a final test, I used the Gem for an observing run on the variable star DM Cygni. DM Cygni is an RR Lyrae star — a pulsating variable that undergoes an abrupt rise in brightness every 10 hours, followed by a gradual return to minimum. To see if this star was behaving on schedule, observations were taken at precise 10-minute intervals over a 2-hour time frame centered on DM Cygni's predicted rise. Even though I had set up the Gem with its polar axis only approximately aimed toward north, the scope remained "true." I returned to the Gem every ten minutes and, with a few twists of the R.A. control, brought the field back into view. I never missed an observation and was able to capture the star's dramatic rise in brightness.

No single telescope can do it all, and the 6-inch Gem is no exception. Because of its relatively fast f/5 focal ratio, it can't generate the high magnifications that an f/8 or f/10 could. Viewing Epsilon (ε) Lyrae with the Gem's high-power eyepiece (a 10mm Plössl that yields 76x) just couldn't split this celebrated "double-double." However, an 8mm RKE eyepiece of my own provided a magnification of 95x and a grand view of this cosmic quintet. The Gem has such fine optics that you can get crisp images of the moon, planets, and close double stars with high-power oculars, sky conditions permitting.

To gather more opinions on the Starsplitter Gem, I brought it to a local astronomy club. A half dozen members converged and, like a team of surgeons, gave it a complete physical. The "patient" has some minor ailments. The eyepiece focusing knob is a tad too close to the main tube (you can pinch your fingers while focusing, if you aren't careful), and the gasket on the tube cap is crimped, making it hard to insert and remove. But overall, the Gem seems to be in excellent health. Most of these astronomical doctors were impressed with how much the Gem offered for its $600 price tag.

Which brings us to the original question: Is the Starsplitter Gem 6-inch reflector too much telescope for the beginner? Perhaps, if that individual is just getting interested in astronomy or younger than 12 years of age. In that case, a good pair of binoculars or a 4-inch telescope would be more appropriate. For the first-time telescope buyer who has good knowledge of the night sky and is patient enough to read through a manual and willing to spend time getting used to a telescope, the Starsplitter Gem 6-inch reflector is the way to go.

Glenn Chaple, a teacher living in Townsend, Massachusetts, is a frequent contributor to Astronomy *and* Odyssey *magazines.*

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Hard Landings, Hot Intergalactic Gas, Moon Maria

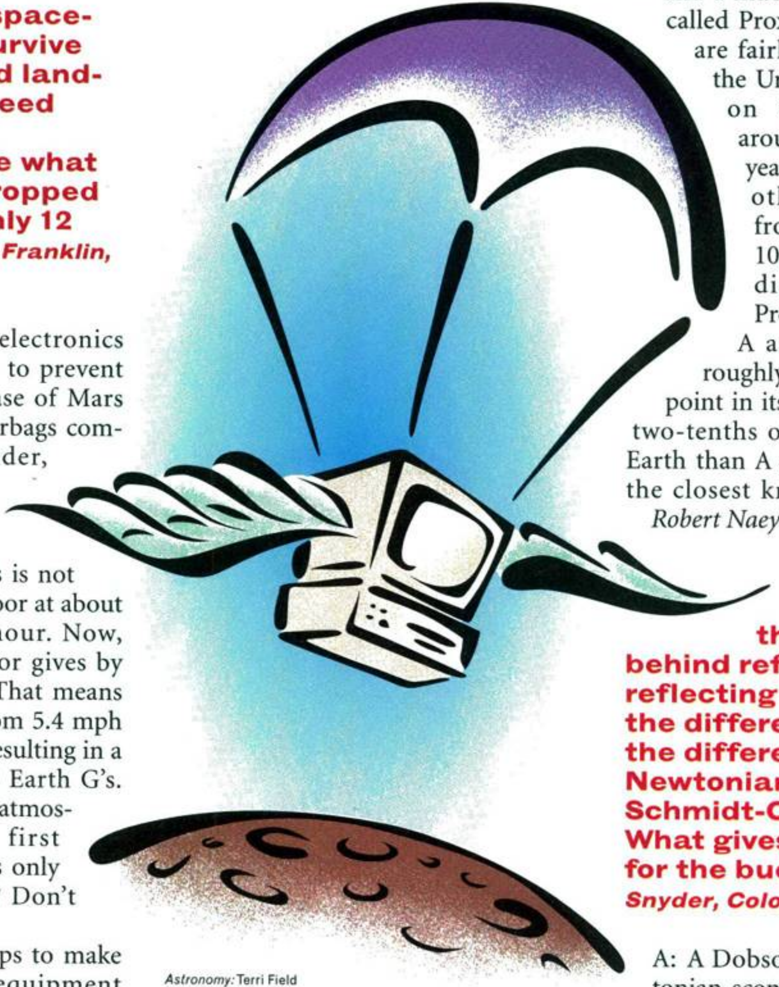
Q: How do NASA's spacecraft electronics survive their relatively hard landings and then proceed to function almost flawlessly? Imagine what happens to a PC dropped from a height of only 12 inches. — ***Greg Gonia, Franklin, Wisconsin***

A: The trick for making electronics survive "hard landings" is to prevent them altogether. In the case of Mars Pathfinder, for example, airbags completely encased the lander, which bounced safely 16 times before coming to a stop. Your PC dropped from a height of 12 inches is not so lucky. It would hit the floor at about 5.4 miles (8.7 km) per hour. Now, assume the hardwood floor gives by about 0.04 inch (1 mm). That means that the PC slows down from 5.4 mph to 0 in half a millisecond, resulting in a deceleration of about 290 Earth G's. Pathfinder hit the martian atmosphere at 16 G's and its first bounce on the airbags was only about 18 G's. The lesson? Don't drop your PC!

Actually, we do take steps to make our sensitive electronic equipment more rugged. We bolt down cables; we bond electronic boards to aluminum plates; we surface mount all the electronic components, and so forth.

We also shock proof. The shock comes not from landing but from explosions used to initiate mechanisms at different phases of the mission. These explosions do as much damage to electronics as a fired shotgun would do to a clock radio mounted on its barrel. So we put tiny shock absorbers at key places to prevent the shock from jolting the electronics and other sensitive areas.

To be sure our efforts will not be wasted, we test the hardware before sending it into space. We spin up the lander in a centrifuge (going as high as 50 G's), fire explosives, measure the shock, and inspect the equipment. We feel confident that it will not fail, even in the worst case environment. — *Rob Manning, Chief Engineer, Mars Pathfinder, Jet Propulsion Laboratory*



Astronomy: Terri Field

Q: Recently my friend and I had an argument. He said that Alpha Centauri is the closest star to Earth at a distance of 4.3 light-years away. I said it was Proxima Centauri. Who was correct? — ***Duke Desabrais, Ottawa, Ontario***

A: You are both more or less correct. Alpha Centauri is a triple star system consisting of Alpha Centauri A and Alpha Centauri B — two stars somewhat cooler and fainter than our sun — and a much smaller red dwarf star called Proxima Centauri. A and B are fairly close together, about the Uranus-sun distance apart on average. They orbit around each other every 80 years or so. Proxima, on the other hand, is far away from both stars — about 10,000 times the Earth-sun distance from A and B. Proxima goes around both A and B with a period of roughly a million years. At this point in its orbit, Proxima is about two-tenths of a light-year closer to Earth than A and B, so it is presently the closest known star to Earth. — *Robert Naeye, associate editor*

Q: I understand the principles behind refracting and reflecting scopes, but not the different types. What's the difference between Newtonian, Dobsonian, and Schmidt-Cassegrains? What gives the most bang for the buck? — ***Victor D. Snyder, Colorado Springs, CO***

A: A Dobsonian is merely a Newtonian scope on a simplified altazimuth mount that pivots up and down and left and right. For the most part, Dobsonians put your money where it's most important: the optics.

If you need a space-saving scope, a Schmidt-Cassegrain is your best bet. These scopes are considerably smaller than Dobsonians and Newtonians but have a similar-size mirror. Schmidt-Cassegrains accomplish this by reflecting the light path back upon itself to cut the optical tube length roughly in half. — *John Shibley, contributing editor*

Q: Is a piece of welder's glass protection enough to safely view the sun? Or is viewing the sun not a good idea? — ***Michael O'Connor, Murray River, Prince Edward Island, Canada***

A: Viewing the sun is always a great idea . . . provided you do it safely with the proper filter. For quick glances without a telescope, pick up a No. 14 welder's glass from a welding or builder's supply store. Shade No. 14 is specialized glass, so don't be surprised if it's a special-order. Count on spending about $10 for a 2" x 4¼" filter, the size that usually fits into a set of welder's goggles. Be sure to hold it in front of your eyes, covering them completely, before looking at the sun.

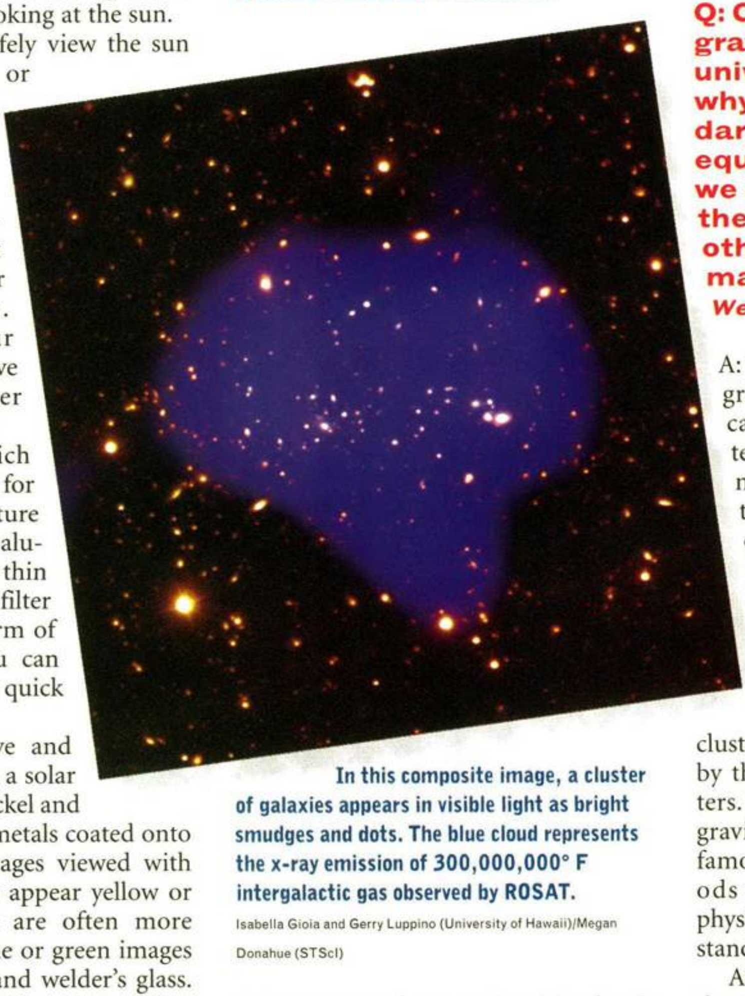
If you want to safely view the sun through binoculars or a telescope, check out the ads in this magazine for glass or mylar solar filters. These filters slide snugly over the front opening of a scope or a pair of binocs. When placing your order, be sure to have the outside diameter measurement handy.

Mylar filters, which cost less than $100 for an 8-inch scope, feature one or two layers of aluminum applied to a thin mylar. This type of filter also comes in the form of $20 "sunglasses" you can slip over you eyes for quick views of the sun.

A more expensive and durable alternative is a solar filter consisting of nickel and chromium or other metals coated onto a piece of glass. Images viewed with these filters typically appear yellow or orange, colors that are often more pleasing than the blue or green images produced by mylar and welder's glass. For an 8-inch scope, plan on spending between $150 and $200 for a filter of this type.

The most expensive option is an Hα filter. It isolates a particularly active wavelength on the visible surface of the sun, known as the photosphere. This visual sweet spot lets us witness huge arcs of hot gas, called prominences, towering thousands of miles into space. The sun's surface appears splotched with sunspots. The view doesn't come cheap; Hα filters cost between $700 and $2,000, depending upon how finely the filter can be tuned to the Hα wavelength. — *John Shibley*

Q: Why is the gas in intergalactic space millions of degrees in temperature when it's thousands of light-years from any stars, when I'm only 93 million miles from a respectable star (the sun) and it's freezing cold in the winter? — ***Dave Kriege, Johnson Creek, Wisconsin***



In this composite image, a cluster of galaxies appears in visible light as bright smudges and dots. The blue cloud represents the x-ray emission of 300,000,000° F intergalactic gas observed by ROSAT.

Isabella Gioia and Gerry Luppino (University of Hawaii)/Megan Donahue (STScI)

A: It may sound counterintuitive, but it is definitely not cold in outer space just outside our planet's atmosphere. Earth is located inside the solar wind, which has a temperature exceeding 180,000° F (100,000° C) at Earth's distance from the sun.

And the gas between galaxies is hot indeed. But the warmth comes not from nearby stars but from gravity as the gas falls into the powerful gravity "well" at the center of the nearest galaxy cluster. The gas molecules are so spread apart, or rarefied (more so than even in a laboratory vacuum), that the gas cools very slowly, and thus it remains hot for billions of years.

However, the temperature refers only to the speeds of the atoms and molecules in the gas and not to the gas's radiated energy. And despite the deceptively high temperatures, you would freeze in both intergalactic space and in orbit around Earth. The spread-out gas molecules mean that very few atoms and molecules actually carry any energy. — *James Kaler, University of Illinois*

Q: Could the force of gravity vary in the universe? Could this be why we need to factor dark matter into the equation to explain why we only see 10 percent of the universe and that the other 90 percent is "dark matter?" — ***Bruce Newman, West Seneca, New York***

A: How do we know that the force of gravity is constant? That's complicated. There are direct laboratory tests, but of course these can only measure the force over short distances. On larger scales, the evidence is indirect. The best evidence that gravity is described by Newton's inverse-square law is that the mass indicated in clusters of galaxies by Newton's law applied to the individual galaxies or to the hot gas in the clusters agrees with the mass indicated by the bending of light by such clusters. This bending of light causes the gravitational lensing that produces the famous arcs. Two independent methods yielding the same result give physicists confidence that their understanding is correct.

As has been known for many years, the total mass in these clusters is much greater than that contained in the visible stars and gas clouds. On the scale of such clusters — and also in smaller objects such as galaxies and larger ones such as superclusters — most of the mass must be in the form of some invisible component, which we call "dark matter."

ask Astro

A good reference for more details on experimental tests of gravity theory is Clifford Will's book *Was Einstein Right?* or my article "The Case of the Dark Matter" in the *1990 Science Year*, the World Book Annual Science Supplement (World Book, Inc., 1989) — *Joel Primack, Department of Physics, University of California at Santa Cruz*

Q: I was taught that Earth's revolution around the sun takes slightly longer than 365 days and therefore we have a leap year every four years to even things out. But I also recall that the added day doesn't work out exactly and thus we skip a leap year every 400 years. Does this mean that 2000 won't be a leap year? — *Keith Hall, Dallas, Texas, and four others*

A: The year 2000 will have a February 29. But as you suspected, the timing of leap years isn't as simple as one every four years.

Our calendar is based on what astronomers call the tropical year: the time it takes for Earth to revolve around the sun with respect to the vernal equinox (the first day of spring), which keeps the calendar aligned with the seasons. The tropical year measures 365.242199 days long — not a number that allows a simple formula for leap years.

The first successful attempt to bring order out of chaos came in 46 B.C. when Julius Caesar instituted a calendar reform that decreed a leap year every fourth year. That gives a year averaging 365.25 days, just 11 minutes and 14 seconds longer than a tropical year. That's not a big discrepancy, but those minutes add up.

By 1582, 13 days had accumulated and the vernal equinox fell on March 11. If the trend continued, Easter would eventually be in winter. To prevent further slippage, Pope Gregory XIII initiated a two-step calendar reform. First, to bring the vernal equinox back to where it was in the 4th century, the calendar dropped 10 days by proclaiming the day after October 4, 1582, to be October 15. Second, the rule for leap years was modified so that years divisible evenly by 100 would not have an extra day unless they were also divisible by 400. Thus 1700, 1800, and 1900 were not leap years, while 1600 and 2000 would be. The Gregorian calendar matches the tropical year to within a day about every 3,300 years. The calendar has since been modified further, so that years divisible by 4,000 are no longer leap years.

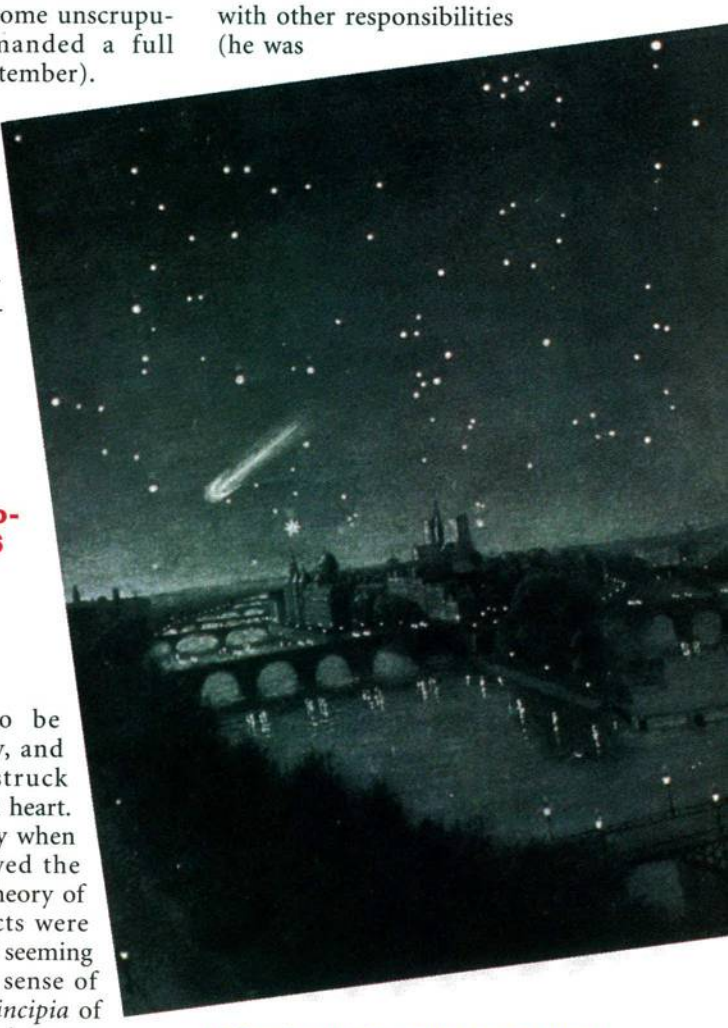
Roman Catholic countries adopted the reform immediately, but most Protestant countries and those under the Eastern church did not. England and the American colonies came on board in 1752, when September 2 was followed by the 14th. Rioting occurred in some areas as people demanded the lost time back (and some unscrupulous landlords demanded a full month's rent for September). Russia stayed with the Julian calendar until the Bolshevik revolution in 1917, when it had to drop 13 days to rejoin the rest of the world. — *Richard Talcott, associate editor*

Q: How did Edmond Halley know that the comet that reappeared every 76 years was the same one? — *Nathalie Moreitz, Sydney, Australia*

A: Comets used to be shrouded in mystery, and their appearance struck terror into the human heart. Until the 17th century when Isaac Newton achieved the breakthrough of his theory of gravitation, no objects were more puzzling in their seeming unpredictability and sense of foreboding. In the *Principia* of 1687, Newton revealed a complex and laborious method that showed that, like the planets, comets moved in predictable orbits around the sun.

Newton applied his method to one case — the comet of 1680 — showing that it moved in a nearly parabolic orbit around the sun. At once, Edmond Halley resolved to apply the same technique to other comets. By 1695, he had begun to suspect that the comet of 1682 had returned on prior occasions to the vicinity of the sun and that it moved in an elongated elliptical path. He wanted to refine his results, but his own observations were not accurate enough. John Flamsteed, the Astronomer Royal at Greenwich, had what was needed, but unfortunately at the time he and Halley were not on speaking terms.

Newton, who was adept at squeezing observations from Flamsteed, obtained those for which Halley had asked. During the next ten years, Halley carried out a "prodigious deal of calculation" when he was not taxed with other responsibilities (he was



A French publication illustrates the bright presence of Comet Halley over the Paris sky in 1910. Seventy-six years later, as Edmond Halley had predicted, the comet returned.

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also deputy comptroller of the mint at Chester and became a commissioned naval officer, sailing his ship the *Paramore Pink* twice across the Atlantic to chart local magnetic variations).

Only in 1705 did he finally get around to publishing his results on comets, which included the orbits of 24 that had passed perihelion between 1337 and 1698. He noticed a striking resemblance in the orbits of the comets of 1531, 1607, and 1682 and concluded that beyond a doubt this was one and the same object moving retrograde around the sun (i.e., clockwise as viewed from above the plane of the ecliptic — the reverse direction to the counterclockwise motion of the planets around their orbits). He calculated the average period was 75½ years and added: "I can undertake confidently to predict the return of the [comet] in 1758 . . . Wherefore if according to what we have already said it should return . . . candid posterity will not refuse to acknowledge that this was first discovered by an Englishman."

He was indeed vindicated on Christmas night in 1758 when a German amateur astronomer, Johann Georg Palitzsch, swept up a faint object in Pisces — a comet approaching the sun, which, when its orbit was worked out, was found to be identical with Halley's. — *William Sheehan, author of* The Planet Mars, *University of Arizona Press*

Q: Why are all the dark lava basins, or maria, on the moon located on the near side, the side that faces Earth, and none on the far side? *— Mark Mumaugh, Cheyenne, Wyoming*

A: Astronomers think the answer lies in the fact that the moon's crust is perhaps up to 31 miles thinner on the near side than on the far side. The reason for this crustal thickness difference is not fully understood, but it may be related to the tidal effect of the Earth being stronger on the moon's near side than on its far side. The moon's cratering record and the Apollo lunar samples tell us that our nearest celestial neighbor was volcanically active for about the first billion years of its history. Molten rock or magma that welled up under the lunar crust was able to break through the thinner near side crust easier than the thicker far side crust, and this is why the great circular impact basins that were formed even earlier in lunar history were filled preferentially on the near side (there are only a few small far side mare deposits). Even though the different appearance of the near side and the far side of the moon is striking, it is interesting to note that the thin lava flows in the maria represent only about 1 percent of the volume of the lunar crust, attesting to the relatively weak role of volcanism in shaping the overall geology of the moon. — *Jim Bell, Center for Radiophysics and Space Research, Cornell University*

Dark lava basins known as maria blemish the moon's near side, but they don't occur on its far side. Bill Hood/Deep Sky Astrographics

Q: With what method are Greek letters assigned to stars in a constellation? I assume that alpha and beta are the two brightest, but where do they get, for example, omicron and omega from, since there aren't 24 stars in any constellation? *— Joshua Metzger, Hamilton, Ohio*

A: The term "constellation" has two meanings: the outline of stars that make the traditional drawn figure and the well-defined area of sky that encloses the constellation. Though the figure might have only a few naked-eye stars, the area might have hundreds.

The brightest stars in the defined area were given Greek letter names in order of brightness by Johannes Bayer in the early 1600s. The alpha star is usually the brightest. The Greek letters are followed by the Latin possessive form of the constellation name, so the brightest star in Lyra (Vega) becomes Alpha Lyrae. But like all standards, there are always exceptions to the rule. In the constellation Orion, Beta Orionis is brighter than Alpha.

Bayer also named some stars in order of position. For example, Alpha through Eta of Ursa Major run along the Big Dipper in an order that does not have much to do with their brightness. He also broke some constellations into parts; the top of Canis Major (the Larger Dog) lettered Alpha through Gamma, even though Gamma is much fainter than the stars in the bottom of the Dog. — *James Kaler* A

CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live. *Astronomy* regrets that due to the large volume of mail, we are unable to publish answers to all questions or respond to each one individually.

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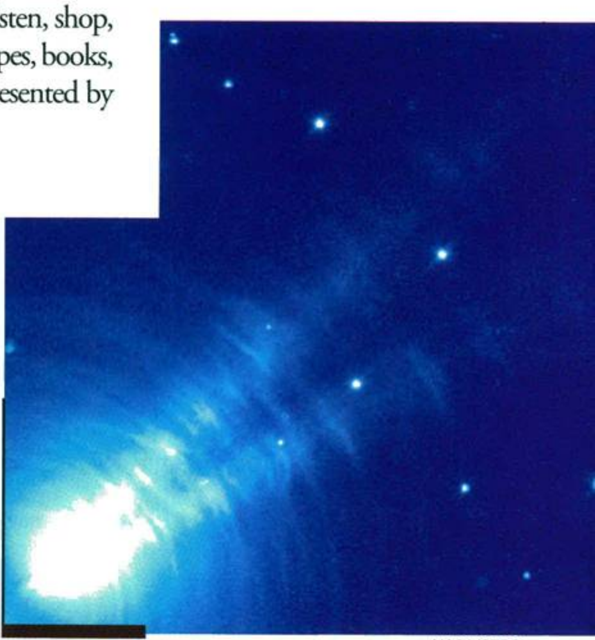

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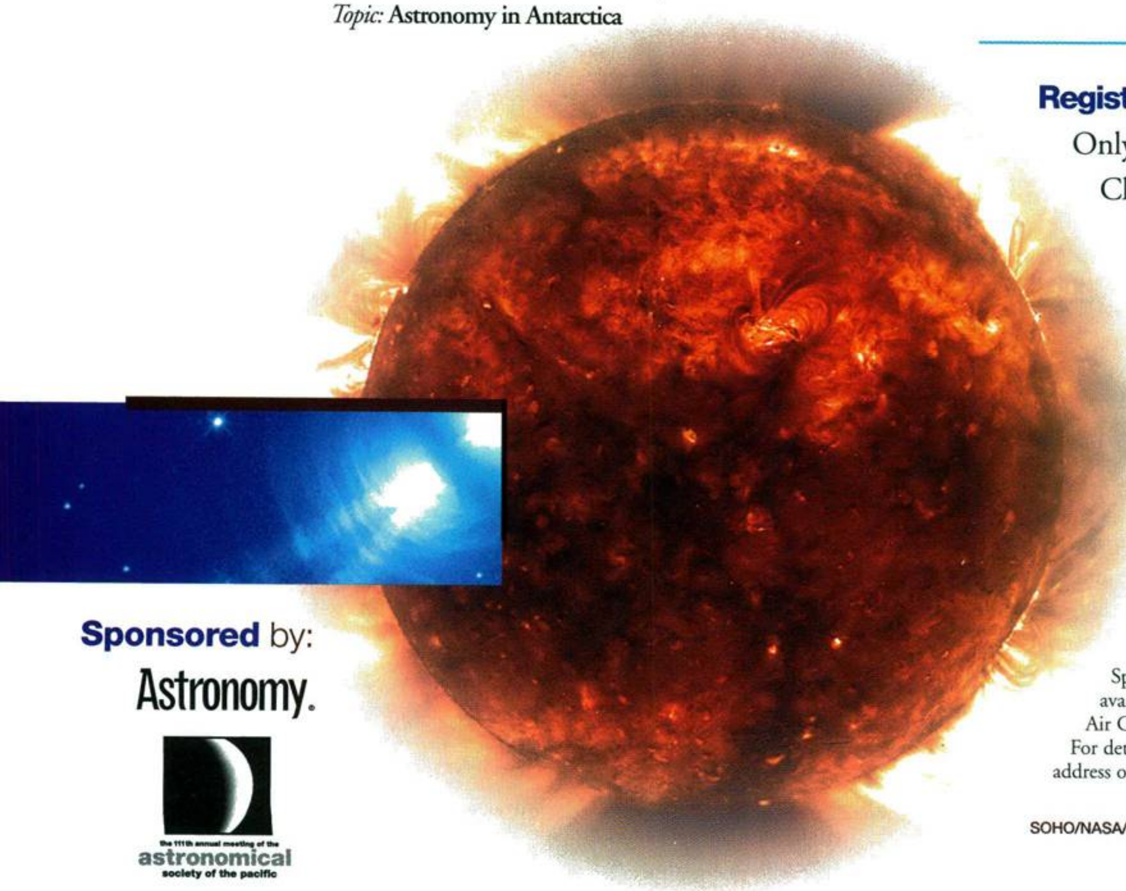

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Celestron International, 2835 Columbia Street, Torrance, CA 90503; phone, (310) 328-9560; fax, (310) 212-5835; website, http://www.celestron.com. (without motor drive) G-3: $ 1,280, G-5: $860.

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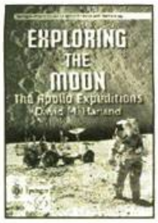

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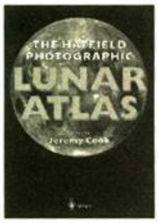

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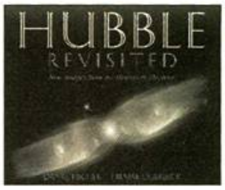

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BOOKS

Nothingness: The Science of Empty Space

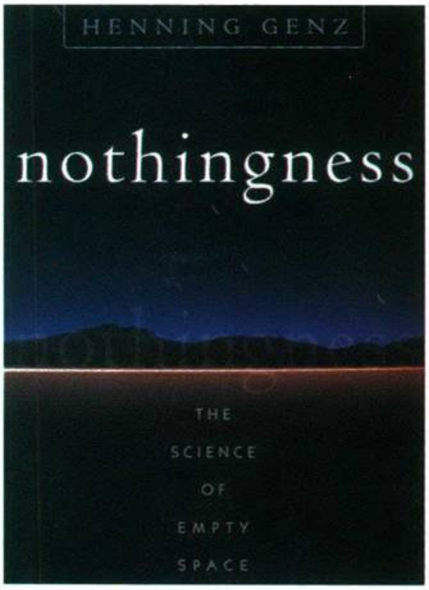
Henning Genz, 340 pages, Helix Books/Perseus Books, Reading, Massachusetts, 1999; ISBN 0-7382-0061-1; hardcover, $30.

▶ Scientists and philosophers have wondered about the nature of empty space for centuries. The idea that space could be completely devoid of matter was absurd to the ancient natural philosophers, who firmly believed that nature "abhors a vacuum" and thus always acts to prevent the formation of a vacuum.

Humanity's fascination with the void of space is intimately related to another question: How did it happen that at some point in time, something appeared out of nothing?

In *Nothingness: The Science of Empty Space*, Henning Genz, a physicist at the University of Karlsruhe in Germany, takes us on an engaging journey of humanity's inquiries into the nature of the vacuum, or void of empty space. When discussing empty space, Genz is not referring to intergalactic space, which is almost a perfect vacuum by terrestrial standards (each atom is located roughly one meter from its nearest neighbor). Instead, Genz is discussing the space between atoms. But this space is not empty, it's filled with light and radiation from various sources. As Genz puts it, "A region of space is not really empty simply by virtue of not containing matter."

In the first chapter, Genz deftly introduces the early history of vacuum studies and the physical underpinnings of our modern day understanding of the vacuum. He asks: "Is it possible to remove 'everything' from a space to create a truly empty space?" This topic has broad ramifications for physics and cosmology and is crucial to our understanding of the origin of the universe.



According to the Big Bang theory, the universe was created out of the random fluctuations of nothingness. Genz draws on quantum mechanics and relativity to make this seemingly absurd statement not only understandable, but believable. Quantum mechanics tells us that we cannot know both energy and time with infinite precision; thus, empty space is never truly empty but contains some minimum, nonzero energy. Relativity tells us that mass and energy are equivalent. Put the two together and you have particle and antiparticle pairs created spontaneously as the quantum energy of space fluctuates (a fact confirmed by experiments). A particle and its antiparticle counterpart annihilate each other and release energy back into the void. This process somehow lead to the Big Bang and the creation of our universe. But what tipped the balance? Physics has yet to provide a definitive answer.

Genz draws on simple analogies to clarify the most challenging concepts. The book also provides a plethora of clever illustrations. Be forewarned, this book requires a fair amount of concentration, and it does not immediately jump into astronomy or cosmology; you will be 200 pages into the text before you see any significant discussion of black holes, neutron stars, or the like.

This is not a criticism, but rather a consequence of the fact that astronomy at its core is dominated by physical processes. Genz artfully presents a cohesive "big picture" which draws on the thoughts and work of ancient Greek philosophers, medieval and renaissance scholars, and scientific giants such as Newton, Maxwell, Einstein, and Hawking. The importance of quantum mechanics, relativity, and elementary particle physics to cosmology is clearly elaborated. If you're interested in the fundamental physics of cosmology and the history of scientific thought, this is a book you definitely don't want to miss.— *Jennifer Birriel*

Deep-Sky Companions: The Messier Objects

Stephen James O'Meara, 304 pages, Cambridge University Press, New York, 1999; ISBN 0-521-55332-6; hardcover, $34.95.

▶ The 109 deep-sky objects listed by French astronomer Charles Messier remain the crown jewels of the northern sky. In *The Messier Objects*, Stephen James O'Meara provides a historical overview of Messier, then explains how to observe the various objects. Short chapters provide detailed descriptions, photos, sketches (drawn by O'Meara), and a sky map of each object. The book closes with a list and description of 20 spectacular deep-sky objects that aren't on Messier's list.

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Astronomy Magazine

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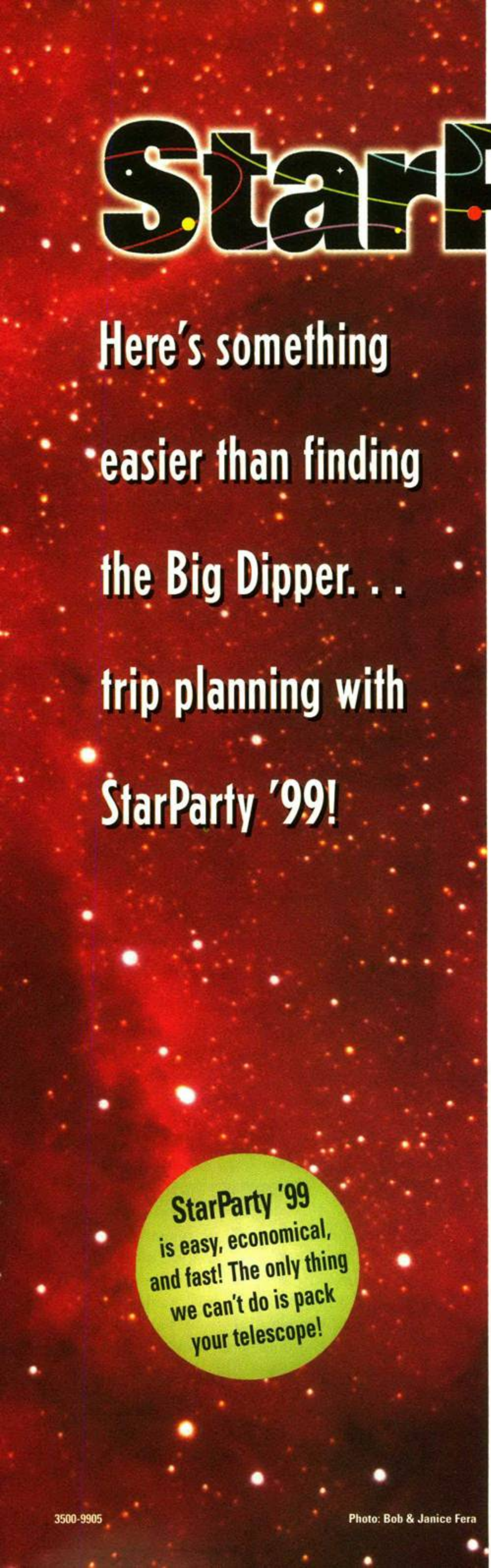

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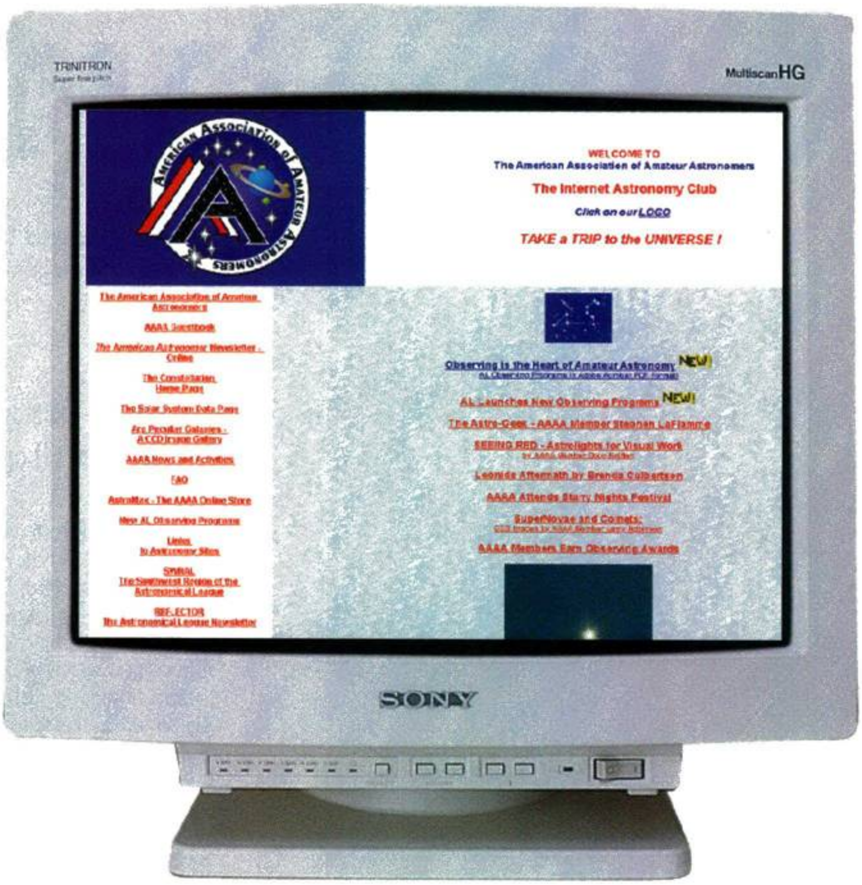

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A BYTES

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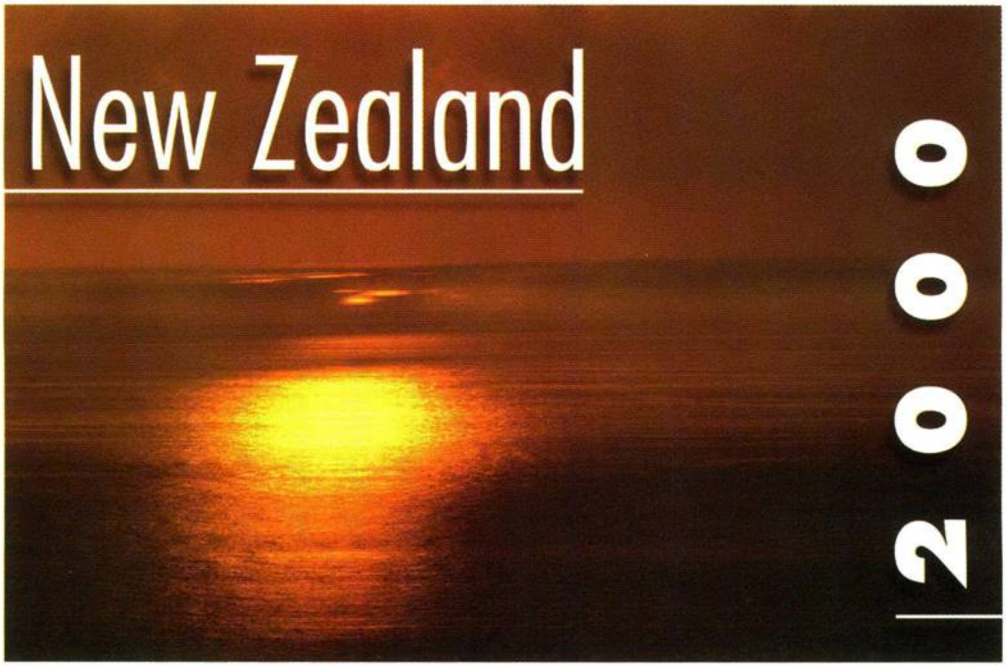

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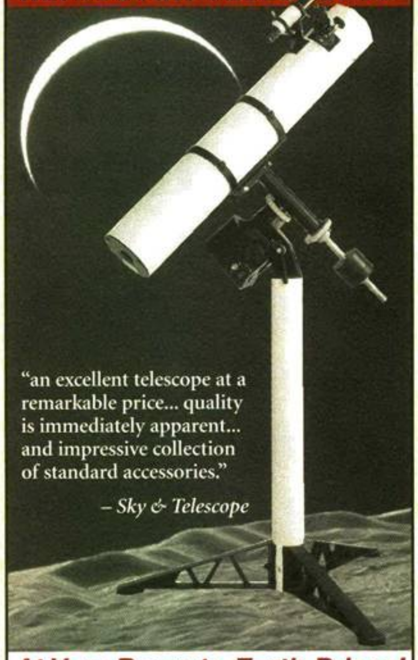

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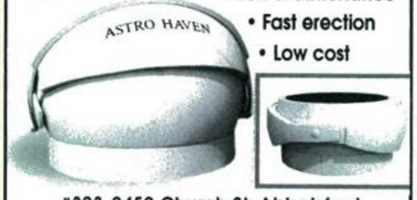

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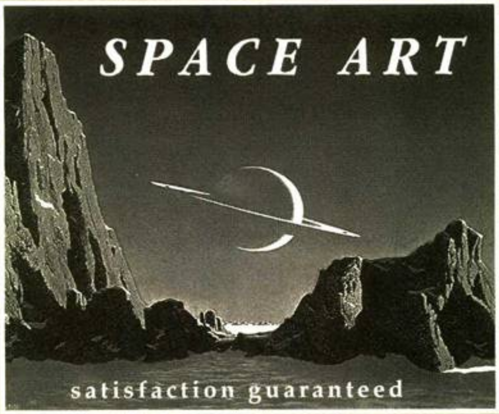

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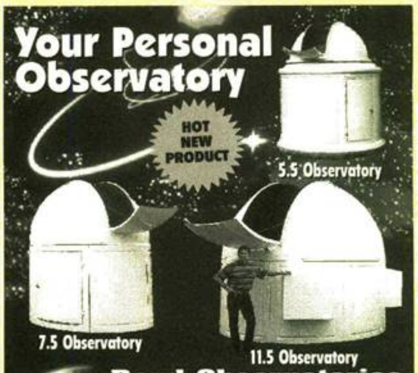

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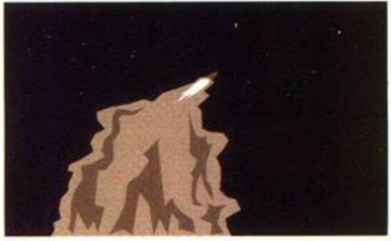

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This year's **Grand Canyon Star Party**, **June 12–19**, will take place on both the South and North Rims of Arizona's Grand Canyon. Observing conditions are excellent, with the nearest town, Flagstaff, 80 miles away. The area offers hiking through the world's largest canyon system, astronomical day trips to Lowell Observatory and Meteor Crater, as well as scenic drives through Monument Valley, the Painted Desert, Flagstaff, Oak Creek Canyon, and Sedona. Twilight talks are scheduled each evening, with cookouts on the weekends. Star party attendees often share their telescope or binoculars with park visitors.

For more information, contact Dean Ketelsen, 1122 East Greenlee Place, Tucson, AZ 85719; (520) 293-2855; e-mail, ketelsen@as.arizona.edu; website, http://www.tucsonastronomy.org.

MAY 28–31
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▶ Camp Oakes, 8 miles east of Big Bear, California. Contact RTMC, 8300 Utica Avenue, Suite 105, Rancho Cucamonga, CA 91730; (909) 948-2205; website, http://www.rtmc-inc.org.

MAY 29
Hurricane Ridge Star Party

▶ Olympic National Park, Port Angeles, Washington. Coordinated by the Port Angeles High School Astronomy Club and sponsored by the National Park Service. Contact John Gallagher at (360) 452-0260; fax, (360) 452-0256; e-mail, jgalla@orca.esd114.wednet.edu; website, http://www.tenforward.com/jffa.

Astronomy: Patricia A. Kurtz

Clear skies top the South Rim of Grand Canyon National Park.

MAY 30–JUNE 3
American Astronomical Society Convention

▶ Chicago, Illinois. Hosted by the University of Chicago. Contact Richard Kron, Yerkes Observatory, 373 West Geneva Street, Williams Bay, WI 53191; (414) 245-5555; e-mail, rich@oddjob.uchicago.edu; website, http://www.aas.org.

JUNE
Astronomy Camps

▶ Mount Lemmon and Mount Bigelow Observatories, University of Arizona, Tucson, Arizona. June 2-9, beginning teenagers; June 11–19, advanced teenagers; June 21–24, educators. Contact Don McCarthy, 933 N. Cherry Ave., Tucson, AZ 85721; (520) 621-4079, e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astro_camp.

JUNE 11–12
Craters of the Moon Star Party

▶ Craters of the Moon National Monument, between Arco and Carey, Idaho. Sponsored by the Magic Valley and Idaho Falls Astronomical Societies. Contact Jay Sneddon, (208) 736-2447; e-mail, jsneddon@aspenpeo.com or Mark Brandon, (208) 357-3540; e-mail, skygaz@srv.net; website, http://members.tripod.com/mvas.

JUNE 11–13
Astronomical League, Mid-States Regional Convention

▶ Morrison Observatory and Central Methodist College, Fayette, Missouri. Hosted by the Central Missouri Astronomical Association. Contact Tom Vaughn, CMAA, P. O. Box 1251, Jefferson City, MO 65102-1251; (573) 761-1108; fax, (573) 634-7854; e-mail, tvaughn@computerland.net; website, http://www.system.missouri.edu/cmaa/cmaa.htm.

JUNE 11–13
Jersey Star Quest

▶ Hope Conference and Renewal Center, Hope, New Jersey. Sponsored by the Amateur Astronomers Association of Princeton. Registration deadline June 1. Contact Greg Cantrell, P. O. Box 2017, Princeton, NJ 08543; (732) 308-3488; e-mail, cantrell@Princeton.edu; website, http://georgenet.net/aaap/starquest.html.

JUNE 11–13
Mason Dixon Star Party

▶ Spring Valley County Park, York County, Pennsylvania. Sponsored by the York County Astronomical Society and York County Parks. Contact Jeri Jones, (717) 840-7226; e-mail, JLJ276@aol.com; website, http://home1.gte.net/dmdewey/mdsp.html.

JUNE 12–19
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▶ South and North Rims of the Grand Canyon, Arizona. Sponsored by the Tucson Amateur Astronomy Association. Contact Dean Ketelsen, 1122 East Greenlee Place, Tucson, AZ 85719; (520) 293-2855; e-mail, ketelsen@as.arizona.edu; website, http://www.tucsonastronomy.org.

JUNE 18–19
Arkansas Star Party

▶ Devil's Den State Park, 30 miles south of Fayetteville, Arkansas. Sponsored by the Arkansas-Oklahoma Astronomical Society, P. O. Box 31, Fort Smith, AR 72902. Contact Joe Roam, (501) 474-4740 or Dale Hall, e-mail, daleh@interserv.com.

JULY 2–5
Universe '99

▶ University of Toronto, Toronto, Ontario, Canada. Astronomy exhibition and lecture series co-sponsored by the Astronomical Society of the Pacific and *Astronomy* magazine. Contact the ASP, 390 Ashton Avenue, San Francisco, CA 94112; (415) 337-1100; website, http://aspsky.org/u99.

JULY 5–9, 11–15
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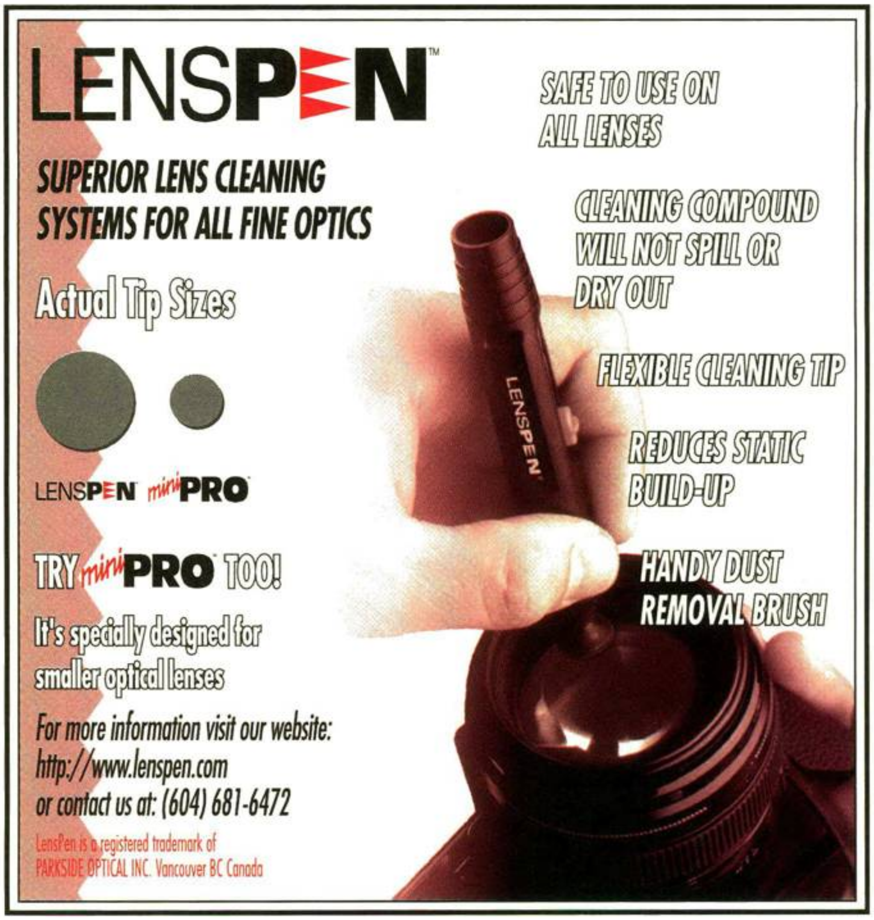
▶ Alfred University, Alfred, New York. Contact the Office of Summer Programs, Alfred University, Saxon Drive, Alfred, NY 14802; (607) 871-2612; e-mail, summerpro@king.alfred.edu; website, http://www.alfred.edu/summer.

JULY 8–9
Rocky Mountain Star Stare

▶ Pike National Forest, 50 miles west of Colorado Springs, Colorado. Pre-registration required. Contact Steve Bygren, c/o CSAS, P. O. Box 62022, Colorado Springs, CO 80962; CSAS event line, (719) 596-3672; website, http://members.aol. com/bygrens/CSAS.html. ■

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley@astronomy.com. Look for additional events at http://www.astronomy.com.



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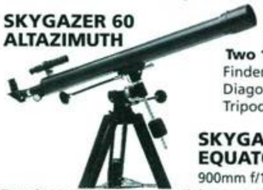

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ANNULAR ECLIPSE

Ring of Fire over the Outback

▶ Of the three types of solar eclipses that occur — partial, annular, and total, I consider a total the best. So why travel 12,000 miles to see a second-rate annular (ring-type) eclipse? I did because on three previous tries my views were obscured partially or totally by clouds. The chance of seeing a perfectly clear annular in Australia was particularly enticing.

I flew the usual grueling 13-plus-hour flight to Sydney and then on to Perth where I teamed up with Joe Cali, who lives in Canberra and whom I met at the 1994 total eclipse in Bolivia. We got to see a little of Perth, a beautiful city with an interesting skyline through which the colorful Swan River meanders.

We took a 30-minute boat ride over to Rottnest Island, discovered by the Dutch in 1696. They found an abundance of what they thought were rats and named the island Ratnest. But when they realized the mammals, now called Quokkas, were actually four times larger than rats, the name of the island was changed to Rottnest. This historic island, attached to the mainland eons ago, is a photographer's paradise and a haven for cyclists with its rugged terrain and deep blue coastal waters of the Indian Ocean. It is a "must visit" when in Perth.

The Northern Lights over Alberta

JOE DRIESSEN

(28mm lens at f/3.8, Kodak Gold 400 film)

Spiral Galaxy NGC 6946

BOB AND JANICE FERA

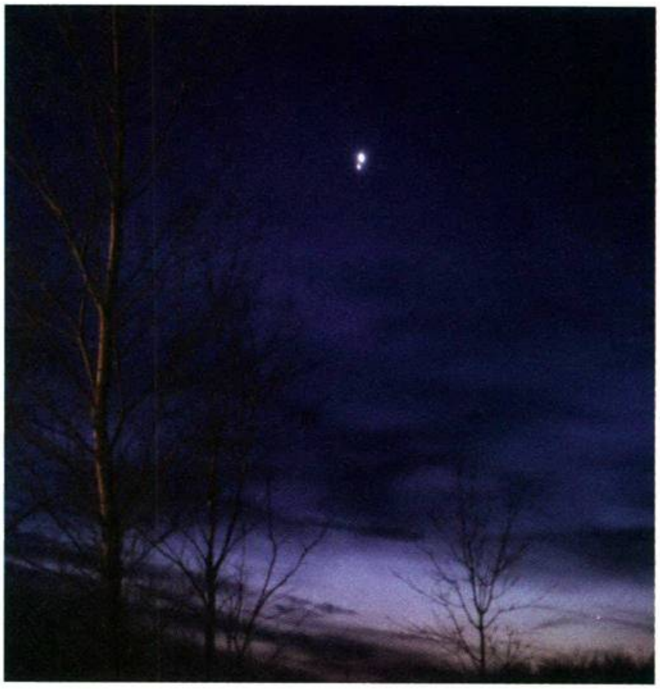
(11-inch f/10 SCT, hypered Kodak PPF 400 film, composite of two 120-minute exposures)

On Sunday, Valentine's Day, we drove north 255 miles to Geraldton, a city on the coast. We arrived early in the afternoon to investigate possible eclipse sites. Joe had an excellent map of the area with even fences and railroad tracks noted. With the aid of my Global Positioning System, we decided on a centerline location about 36 miles east of Geraldton in the Australian outback — complete with plenty of sweat-seeking flies, red and black ants, and some wind.

Tuesday we packed our lunch, cold drinks, and equipment and headed to our site. Peter and Evon Anderson from Brisbane soon joined us. We four had the entire site to ourselves except for a billion flies. The temperature was 105° F when I set up under the shade of a tree. I was still calibrating my instruments when Peter announced first contact. Despite fighting flies and acclimating to the heat, we finally had everything under control. There was just a slight, pleasing, and welcome breeze.

It is a great feeling to have nothing but clear blue skies on eclipse day. As the partial eclipse progressed toward annularity, the surrounding sky became a deep blue with the planets Venus and Jupiter sparkling to the East. At mid-annularity the perfect ring (indicating we were right on the center line) occurred as predicted at 3:28:55 P.M. According to my video record, annularity lasted for 28 seconds.

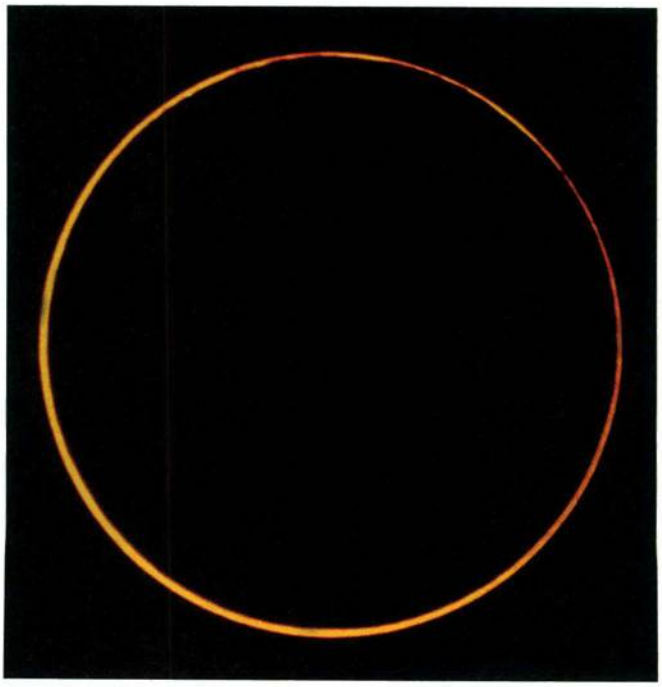
The eclipse caused a variety of effects on the surrounding environment. As for animal behavior, the big thing I noticed was the appearance of ants all over



Venus, Jupiter, and Mercury

STEPHEN BARNES

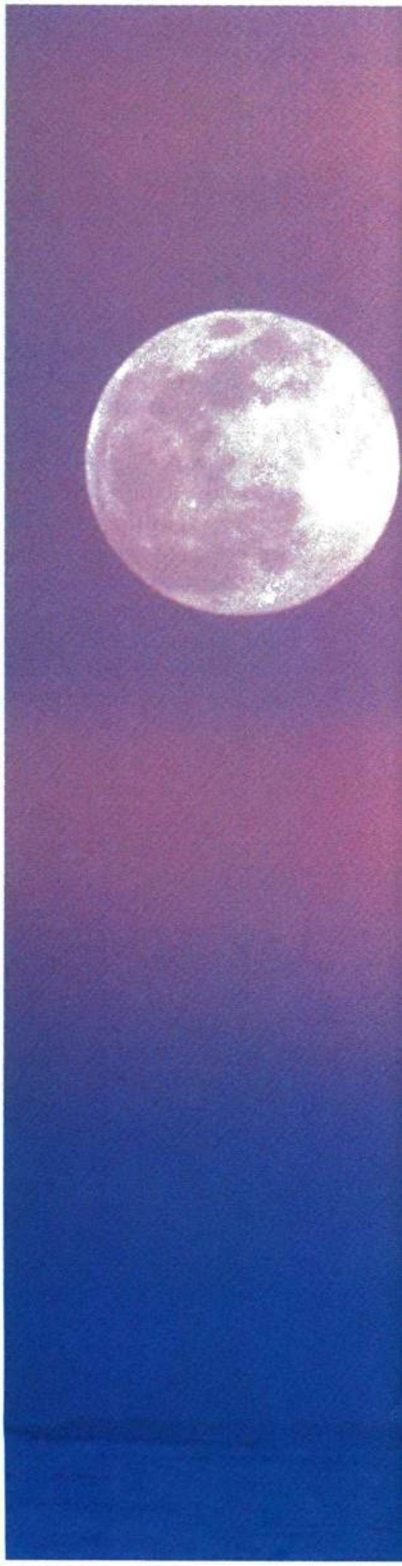
(70mm lens at f/4, Kodak E200 slide film, 8-second exposure taken February 23, 1999)

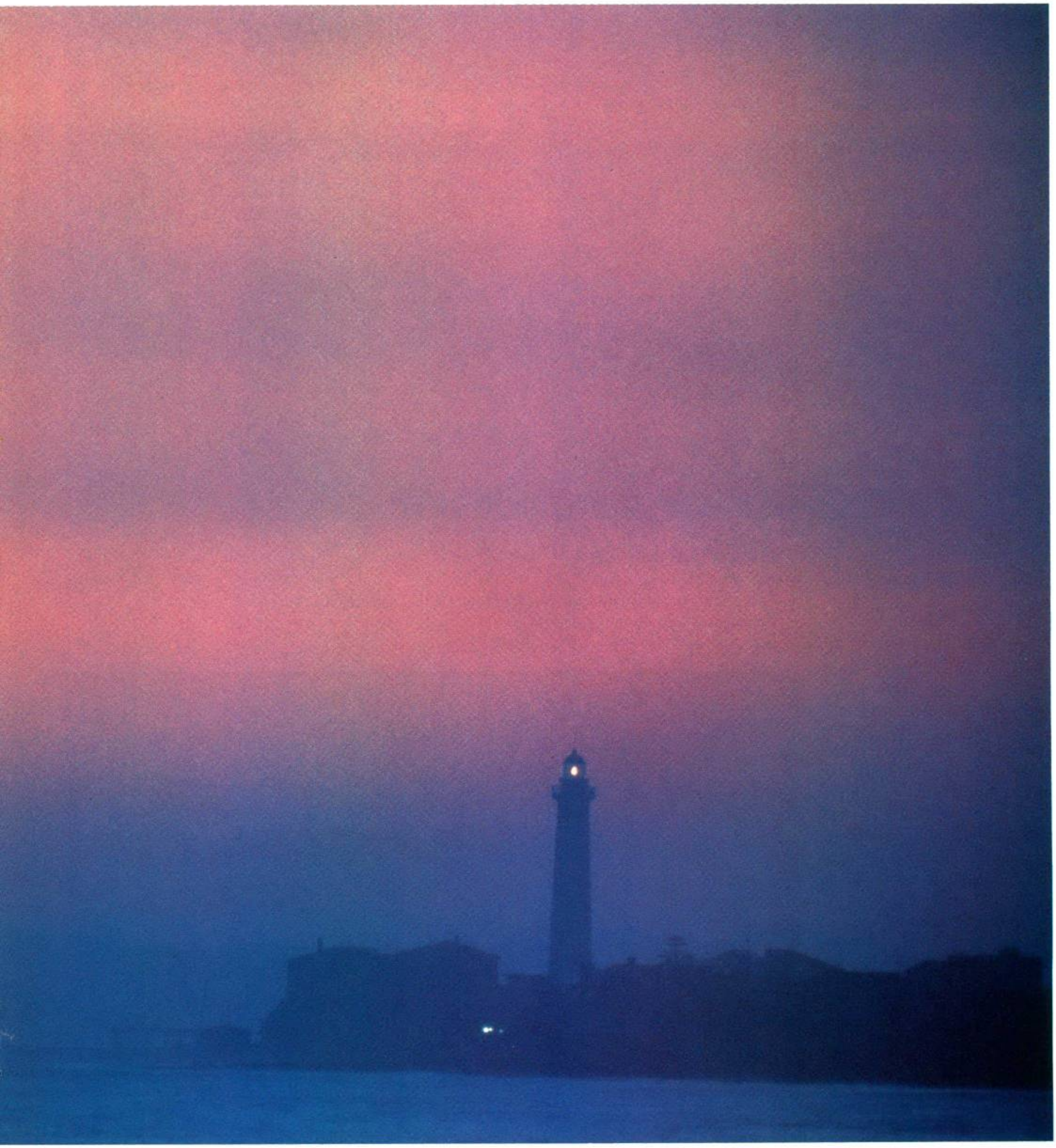


Seconds to Mid-Annularity

ERNIE PIINI

(3.5-inch f/11 Maksutov-Cassegrain scope, Fuji Sensia 100 film, 1/2000-second exposure taken February 16, 1999)





Moon and Lighthouse

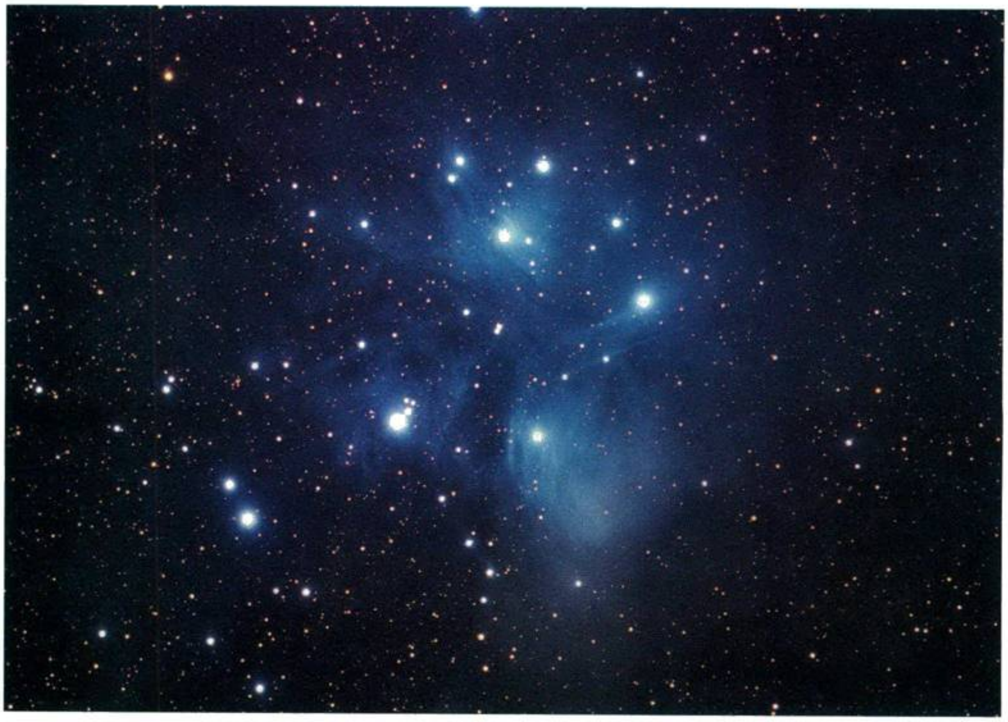
GIANNI TUMINO

(2.8-inch refractor at f/7.4, Kodak Elite II 100 ISO film, composite of 1/30-second exposure [landscape] and 1/125-second exposure [moon]) the ground as the eclipse progressed. Few were around before this event. The temperature decreased from 105° F to 88° F just after the ring of fire began to break up, for a total drop of 17° F. No humidity recordings were attempted. The winds were a mild 5 to 10 miles an hour throughout the period up through annularity, but increased to about 50 miles an hour about 4 minutes later. Thank goodness it didn't appear before then as it would have seriously hampered my results.

The biggest treat outside of seeing the dramatic "ring of fire" was another view of the southern skies. It is so dark in the outback of Western Australia that the view of the night sky is unbelievable. The Southern Milky Way with the Southern Cross, Eta Carinae Nebula, and Alpha and Beta Centauri embedded in it (to name a few) is like seeing heaven. The Magellanic Clouds, large and small, do look like clouds. Our northern constellations Orion and Leo appear high in the sky, upside down.Such a wide array of deep-sky treats would be unheard of to northern observers. I love those skies down under.

Saturday morning, February 20, began at 4 A.M. as Joe and I both had early flights out of Perth. We bade farewell and headed home on our separate paths. I once again "Waltzed My Matilda (Telescope)" and new-found memories back to California.

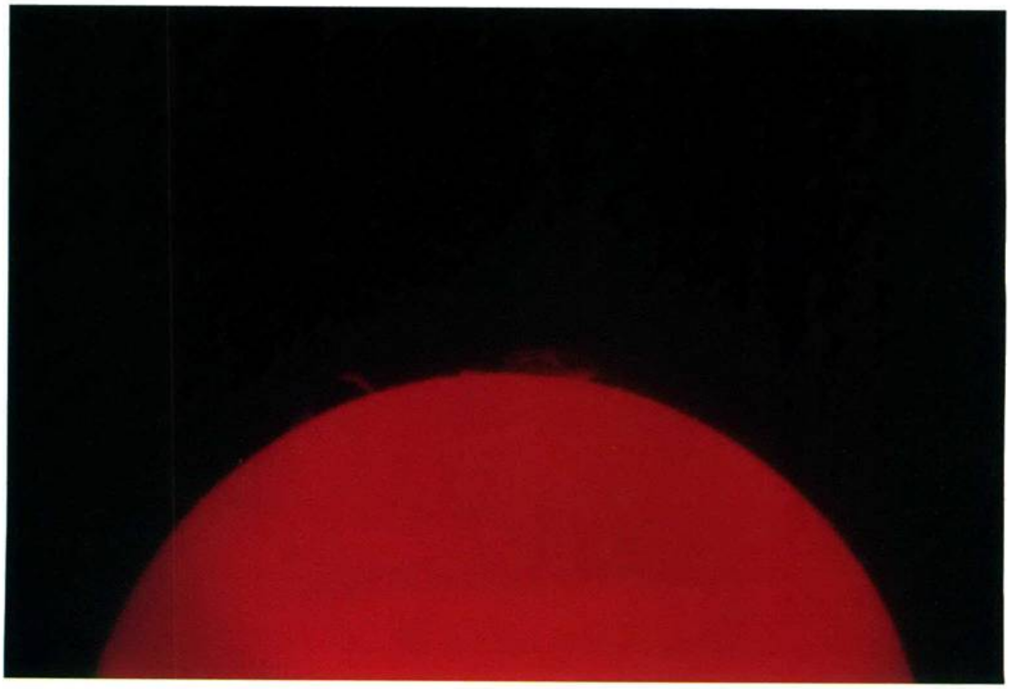
You can read other eclipse reports by Ernie Piini on Fred Espenak's web page at http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html.



The Pleiades Cluster (M45)

MIKE FIEST

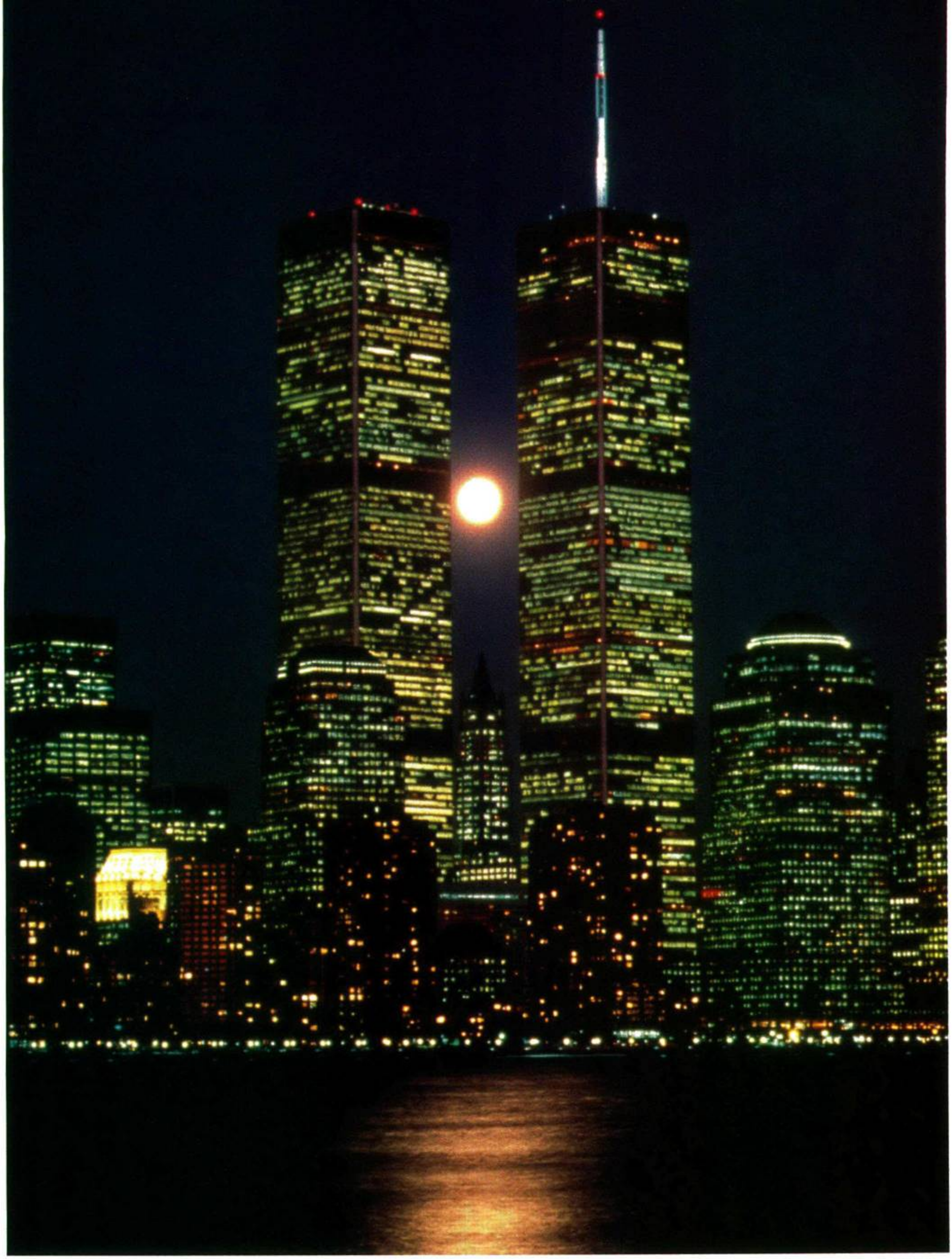
(6-inch f/7 refractor, hypered Kodak PPF 400 medium format film, composite of two 60-minute and one 25-minute exposures)



The Active Sun

RON GATTIE

(10-inch SCT, Hα filter, Kodak Ektachrome 100 film, 1/15-second exposure)

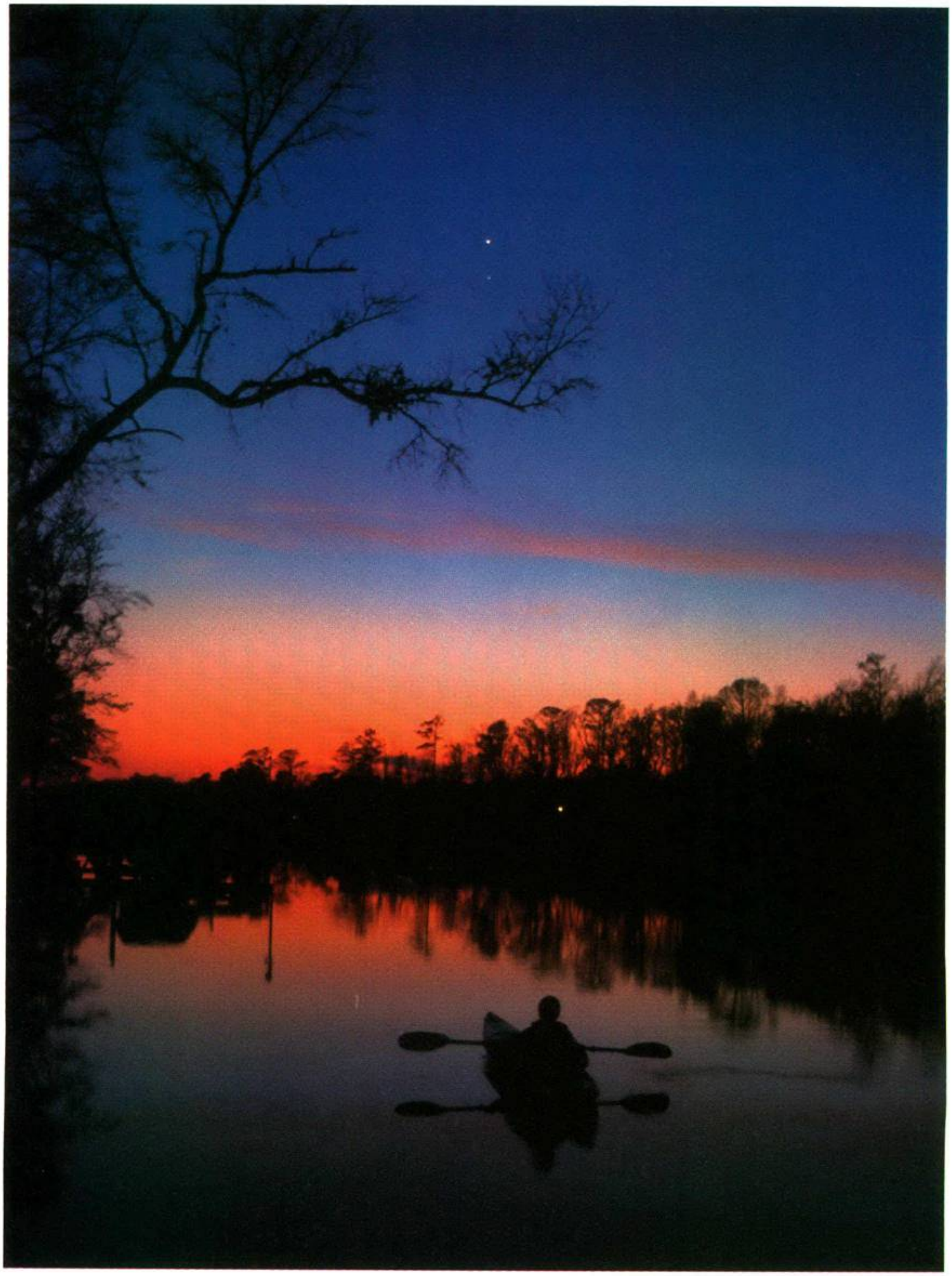


Moon between Twin Towers, New York City

LARRY MAMMONE

(105mm lens at f/16, Kodak Ektachrome 100vs film, 20-second exposure taken November 2, 1998)

This month's best astrophoto



A Tranquil Meeting of Venus and Jupiter

MICHAEL AND DALE SLEAR

(Fujichrome 100 film, ¼-second exposure at f/2.8 taken February 24, 1999)

Michael Slear and his son, Dale, took this serene scene of the Venus/Jupiter conjunction from their backyard on the Intracoastal Waterway in Myrtle Beach, South Carolina.

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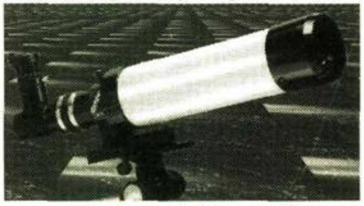

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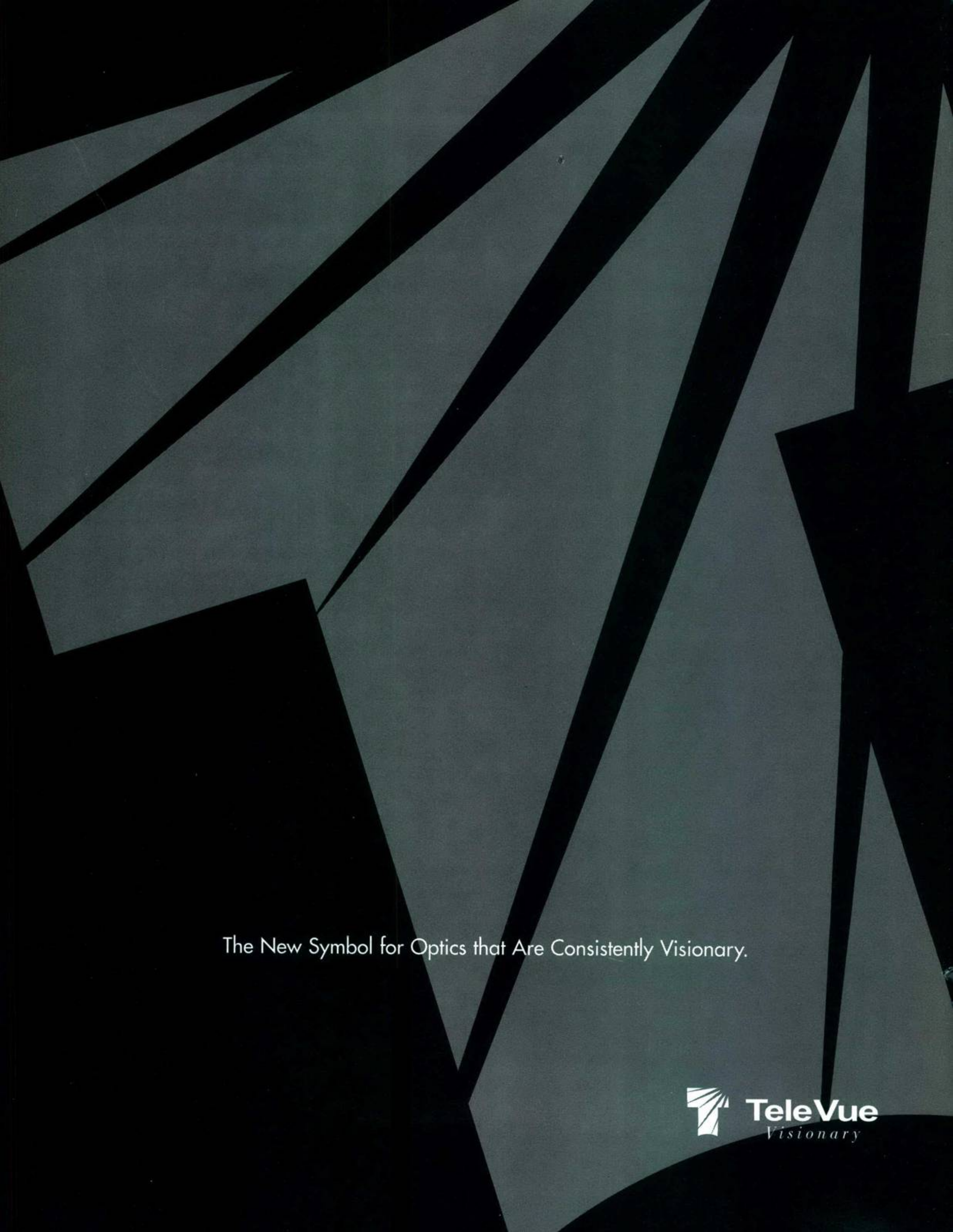
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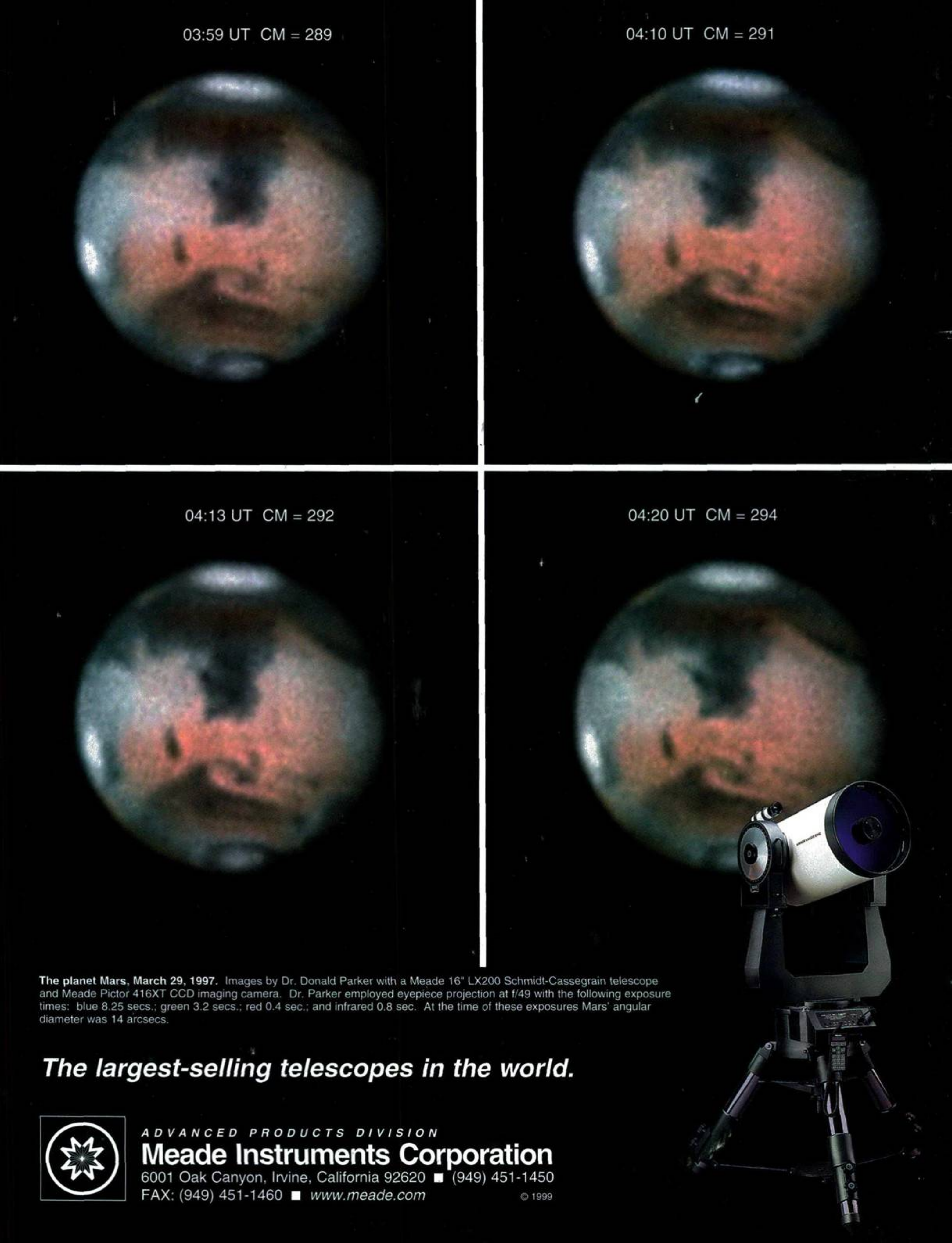

The planet Mars, March 29, 1997. Images by Dr. Donald Parker with a Meade 16" LX200 Schmidt-Cassegrain telescope and Meade Pictor 416XT CCD imaging camera. Dr. Parker employed eyepiece projection at f/49 with the following exposure times: blue 8.25 secs.; green 3.2 secs.; red 0.4 sec.; and infrared 0.8 sec. At the time of these exposures Mars' angular diameter was 14 arcsecs.

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